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SCOUTING, QUARANTINE AND CONTROL FOR THE EUROPEAN CORN BORER, 1917–1926

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UNITED STATES DEPARTMENT OF AGRICULTURE WASHINGTON, D. C.

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INTRODUCTION

Control and repressive measures directed against the European corn borer (*Pyrausta nubilalis* Hübner) have been conducted up to the present time with the primary purpose of preventing, or restricting, the long-distance dispersion of the insect and of developing measures designed to prevent the accumulation of the pest in destructive numbers.

[1] The investigations reported in this bulletin, covering the period from the spring of 1919 to January 1, 1927, have been conducted by L. H. Worthley and D. J. Caffrey, under the successive direction of W. R. Walton, Entomologist in Charge, from the spring of 1919 to September, 1923, Geo. F. Dean, Senior Entomologist in Charge, from September, 1923, to June, 1925, and W. H. Larrimer, Senior Entomologist in Charge, Division of Cereal and Forage Insects, from August, 1925, to the present. To these men many thanks are expressed for their advice, cooperation, and supervision. Thanks are also extended to the following men in the Bureau of Entomology who have contributed to the information contained in this bulletin: R. A. Vickery, E. G. Brewer, R. S. Clifton, H. N. Bartley, Saul Phillips, T. R. Richardson, C. W. Lewis, B. E. Hodgson, F. W. Poos, L. H. Patch, Phillip Luginbill, R. A. Blanchard, K. W. Babcock, W. O. Ellis, W. D. Whitcomb, J. E. Silver, D. H. Craig, D. S. LaCroix, L. B. Scott, F. S. Vidler, H. P. Wood, F. L. O'Rourke, G. W. Still, P. A. Howell, H. J. Cronin, R. C. Thomas, K. B. Lowry, O. J. Teel, H. B. Richardson, A. J. Balzar, H. S. Peters, B. E. Montgomery, L. L. Pierce, O. L. Cartwright, E. G. Moore, J. H. Harman, F. W. Grigg, L. B. Sanderson, C. E. Hofer, H. H. Hodgkiss, and George Wishart. The photographs appearing herein were taken by B. E. Hodgson, Corliss Cramer, W. H. Weible, L. H. Patch, and F. W. Poos; and the drawings were made by R. E. Snodgrass.

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This program has involved the establishment of quarantines by the Federal authorities and by the various States concerned, which prohibit the movement out of infested areas of all plants and plant products which are likely to harbor the European corn borer. The limits of such infested areas were determined by field scouting, and the plants and plant products included in the quarantine were ascertained by careful investigation in the field. To determine the most effective control and repressive measures in areas actually infested by the insect, extensive experiments and field observations have been conducted in the infested areas of the United States (New York, Pennsylvania, Ohio, Michigan, Indiana, and New England), and in central Europe, where the corn borer has been established for a long time.

Judging from results thus far obtained, it is evident that the major control efforts should be directed toward mechanical measures and cultural practices leading to the utilization or destruction of plants and crop residues containing the corn borer, particularly by feeding such material to livestock, by clean plowing, or by burning. These should be supplemented by preventive agronomic adaptations in the culture of corn, particularly certain changes in farm practices (such as the elimination of the practice of disking standing cornstalks or high corn stubble in infested areas) and the use of corn varieties least susceptible to severe injury by the corn borer, combined with a program of planting such varieties late enough, in areas where the borer is numerous, to escape serious infestation and yet produce satisfactory yields.

Although the efforts toward control have included an extensive educational and demonstration program emphasizing the fact that economic control is possible and practicable by means of the "clean-up" methods described in detail later in this bulletin, the writers are of the opinion that voluntary cooperation in the suppression of the corn borer can not be depended upon to accomplish results. There must be legislation, enacted by State governments, compelling the universal adoption of clean-up measures. Similar difficulties have developed in the instance of other insect problems of an emergency nature, and these have been solved in a satisfactory manner only by the enactment of compulsory legislation.

Details pertaining to the bionomics of the European corn borer have been reported upon in a separate bulletin (*4*),[2] and will therefore be discussed only briefly in this bulletin.

DISTRIBUTION AND BIONOMICS OF THE CORN BORER

DISTRIBUTION OF THE CORN BORER IN THE UNITED STATES

The European corn borer was discovered in the United States in 1917 (*6, p. 147*). At that time it was found throughout an area of approximately 100 square miles located immediately north and northwest of Boston, Mass. At present (January 1, 1927), it is known to be present and well established in two large separate areas (fig. 1) comprising a total area of approximately 93,000 square miles. In addition to these well-established infestations, the corn borer is known to be present in several isolated areas, including (1) the western

[2] Italic numbers in parentheses refer to "Literature Cited," p. 142.

end of Long Island, N. Y., (2) Staten Island, N. Y., (3) Bayonne and Jersey City, N. J., (4) scattered townships along the shore of Long Island Sound in Connecticut, (5) the township of Yellow Head, Kankakee County, Ill., and (6) the township of Galien, Berrien County, Mich.

PLANTS ATTACKED BY THE INSECT IN THIS COUNTRY

Corn is injured by the larvæ of the European corn borer to a greater extent than any other cultivated crop attacked by the insect in this country. All types and varieties of corn are involved, including dent corn, sweet corn, pop corn, and flint corn. In the one-generation area about Lake Erie, corn is practically the only crop that has been injured; but a light infestation has been found in these

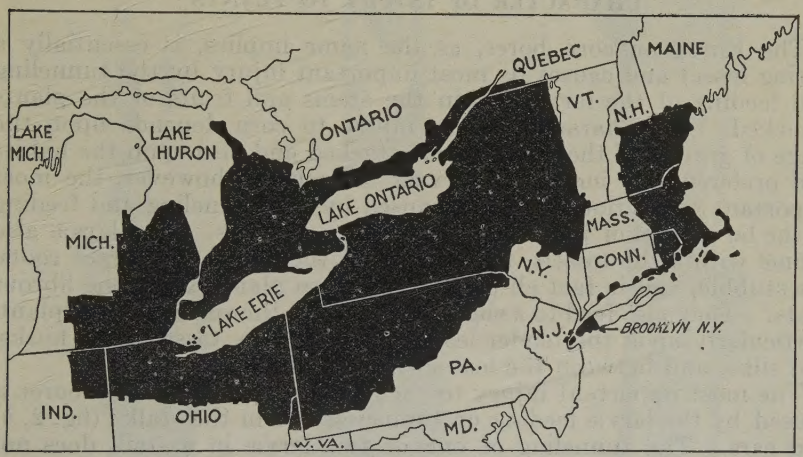

FIG. 1.—Map showing areas quarantined on account of the European corn borer in the United States, to January 1, 1927. Small areas of infestation in Connecticut and in the New York Bay region are indicated, as well as the approximate area infested by the corn borer in Canada

areas in the more susceptible weeds. Near Silver Creek, N. Y., a few borers also have been found in some of the cultivated crops and flowering plants, including soy bean, sorgo, broomcorn, millet, dahlia, and cosmos (*4, p. 23*). In the two-generation area of New England sweet corn and flint corn have been severely injured, and many other cultivated crops also serve as hosts of the corn borer. Rhubarb, beet, celery, bean, pepper, dahlia, aster, gladiolus, chrysanthemum, and zinnia frequently are infested in that area and small losses occur in commercial plantings (*4, p. 56–65*). Because of the danger of disseminating the insect through shipments of vegetables and cut flowers from the infested area of New England, it has been necessary to enforce a quarantine (p. 18) against the States of this group, requiring an inspection of shipments of certain vegetables and flower crops before they are allowed to move out of the infested area.

In the infested area of New England, where two generations of the corn borer develop each year, many species of weeds are commonly infested. Certain of these weeds, notably dock (Rumex spp.), cocklebur (Xanthium spp.), smartweed (Polygonum spp.), and pigweed (Amaranthus spp.) are favorite food plants of the corn borer.

Since extensive areas of susceptible weeds are present in and around certain of the large cities, particularly Boston and New York, the occurrence of the corn borer in weeds presents a very difficult problem in preventing the spread of the pest. Unless treated properly, such areas may constitute reservoirs of infestation from which many thousands of moths will emerge to contribute to the natural dispersion by flight and to infest seriously the cultivated crops in near-by areas. In a previous publication (*4, p. 70*) reference was made to certain large weed areas in the environs of Boston where as many as 406,000 borers per acre were found in dense weed growths. Weed areas of this description must be eliminated of course by burning them during the late fall, winter, or spring, or by spraying them with herbicides during the summer before the plants reach maturity.

CHARACTER OF INJURY TO PLANTS

The European corn borer, as the name implies, is essentially a boring insect and causes its most important injury by the tunneling and feeding of the larvæ within the stems and fruits of the plants attacked. The character of the injury to corn depends upon the stage of growth of the plant when attacked and also upon the habits and preference of individual larvæ. In general, however, the most important and serious injury is caused by the tunneling and feeding of the larvæ within the stalks, ear stems, and ears. The larvæ also tunnel within the tassels, the midribs of the leaves, the brace roots, the stubble, and in fact all parts of the corn plant except the fibrous roots. They also feed to a slight extent upon the surface of the plant, particularly upon the tender leaf blades (fig. 38), tassel buds, husks, and silks, and between the leaf sheaths and stalks.

The most important injury to corn by the European corn borer is caused by the larvæ feeding or tunneling within the stalks (fig. 2, *b*) and ears. The tunneling of one or two larvæ in a stalk does not always cause appreciable damage; but where, as frequently occurs, several or many borers are tunneling or feeding within the same stalk, it becomes reduced to a mere shell filled with frass and particles of decayed and putrefied plant matter. Naturally the stalk is greatly weakened by this type of injury, and eventually it collapses and breaks over at one or more places. (Fig. 3.)

It is evident that material injury to the stalk may indirectly affect the development of the ear by interfering with the supply of nutriment, the seriousness of such injury depending, of course, not only upon the stage of development of the ear during the maximum period of injury but also upon the degree of injury to the stalk. In instances of severe infestation, at least, the greater part of the grain loss caused by the corn borer may be attributed to this indirect injury. The ear may be entered directly by the borers (fig. 4) at any stage of their development, at its tip, base, or side, or it may be entered indirectly through the short stem by which the ear is attached to the stalk. Ordinarily the ear is entered at its tip (fig. 5) by small borers which feed first upon the silk or the tender portion of the husk, subsequently working their way down into the cob (fig. 6) and grain. Injury of this nature to ears of sweet corn (fig. 7) renders them unsalable in the market or at the canning factory. Injury to the ear stem, when severe and occurring early in its development,

may interfere with the supply of nutriment to the ear. Moreover, the ear stem frequently is so weakened by such injury that it breaks over before the ear completes its development. Many ears thus

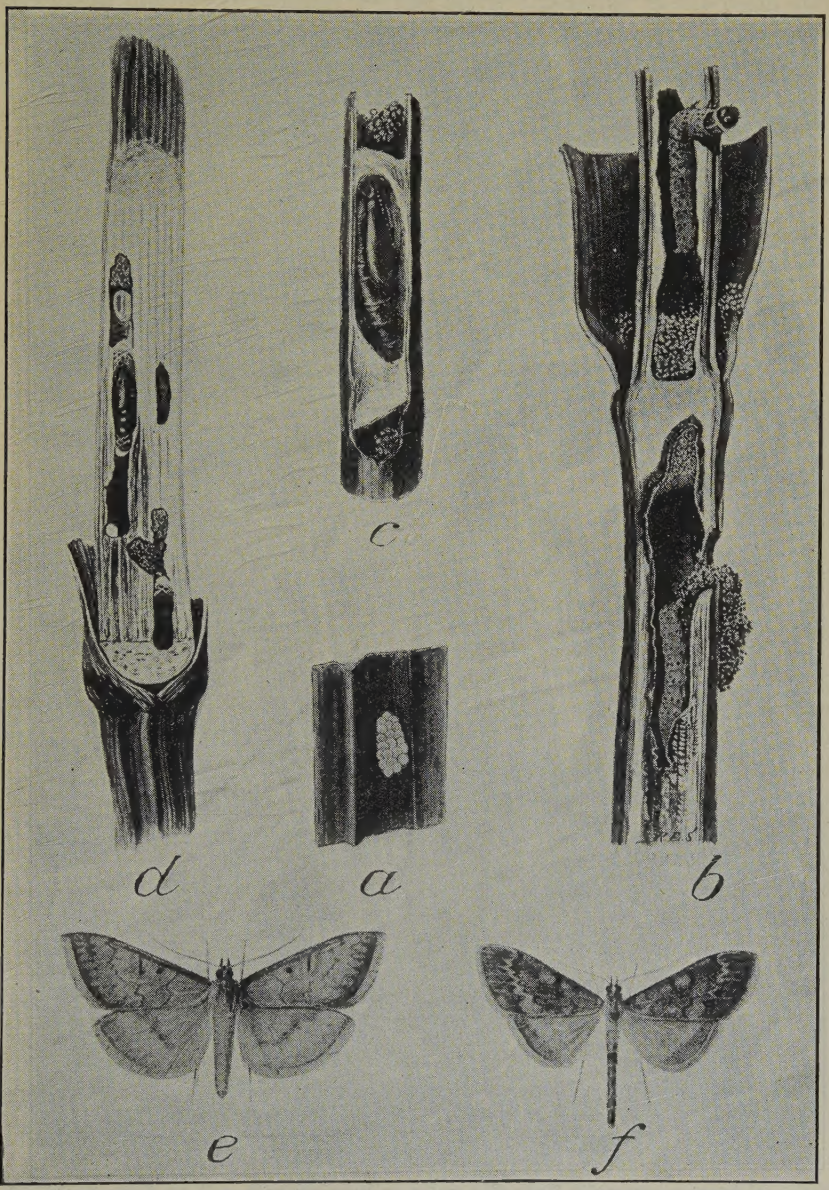

FIG. 2.—The European corn borer: *a*, Eggs; *b*, cornstalk sectioned to show larvæ in their burrows; *c*, cornstalk sectioned to show pupa inclosed within pupal chamber; *d*, cornstalk sectioned to show pupa inclosed within pupal chamber in dry cornstalk; *e*, female moth; *f*, male moth. All (except *d*) about 1½ times natural size

affected fall to the ground long before harvest and are subject to deterioration by rots and other destructive agencies. Even where the infested ears (fig. 8) remain attached to the plant the injury

often is increased by the ingress of rots and molds, which aid in reducing even slightly infested ears to a soft decaying condition, thus sometimes entirely destroying their food value.

FIG. 3.—"Close-up" of hill of sweet corn ruined by the European corn borer. Stalks sectioned to show extensive damage within. There were, on an average, 37 borers per plant in this field

Perhaps the most conspicious injury to corn is caused by the borers tunneling in the tassel stalk, which causes it to break over (fig. 9), although many infested plants do not exhibit a broken tassel.

In beet, rhubarb, and celery the borers tunnel principally in the leafstalks and in the larger veins of the leaves, and frequently they enter the root of beets. Dahlia, aster, chrysanthemum, and similar flowering plants are injured by the larvæ tunneling in the main stem or in the flower stalk. Such injuries frequently prevent proper

FIG. 4.—External view of ear, showing extruded frass and numerous punctures caused by larvæ of the European corn borer. (Caffrey)

development of the flower and render affected plants unsalable. The point should be emphasized that the discussion with regard to corn-borer injury to plants other than corn applies only to the two-generation area of New England, under present conditions. A more complete discussion of the habits of the corn borer will be found in a previous publication (*4, p. 90–117*).

DESCRIPTION OF THE CORN BORER

The female moth (fig. 2, *e*) has a robust body and a wing expanse of a little more than an inch. The general color is variable and

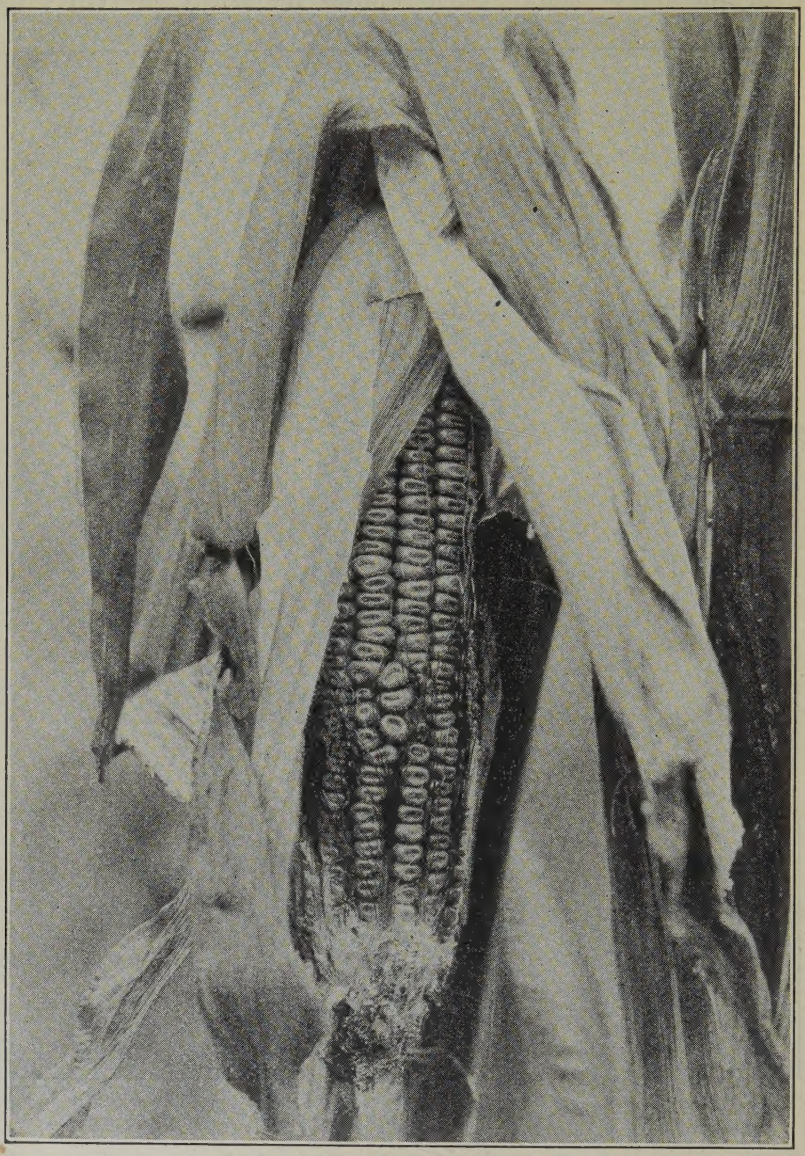

FIG. 5.—Ear of dent corn with husks removed to show typical damage to tip of ear by larvæ of the European corn borer. The cob was also infested by the larvæ

represents all shades from pale yellow to light brown. The outer third of both the fore wing and hind wing is usually crossed by two narrow zigzag lines darker than the rest of the wing. The male moth (fig. 2, *f*) has a slender body, is slightly smaller in wing expanse,

and is usually much darker than the female. The general color varies from pale brown to dark brown, sometimes with a blue tinge. The outer third of the wing usually is crossed by two narrow zigzag streaks of pale yellow, and frequently there are small pale-yellow areas on the fore wings.

The egg (fig. 2, *a*) is nearly flat and about one twenty-fifth of an inch in diameter. It is white when first deposited, but later changes

FIG. 6.—European corn-borer injury to grain and cob of flint corn. Cobs sectioned to show borers within

to pale yellow, becoming darker just before the young larva or borer hatches therefrom.

The full-grown corn borer (fig. 10) is nearly an inch long and one-eighth of an inch thick. The head is dark brown or black. The upper surface of the body varies from light brown or dark brown to pink. Each segment bears a row of small, dark-brown spots, and several narrow, dark-brown or pink lines extend lengthwise of the body. The under side of the body is flesh colored and devoid of markings.

SEASONAL HISTORY

When considering general control measures for the European corn borer, it is important to remember that in the more western areas of infestation, including New York, Pennsylvania, Ohio, Michigan, Indiana, and West Virginia, the insect is single-brooded (has one generation) and confines its activities principally to corn, whereas in New England it is two-brooded (has two generations) and attacks a great variety of plants (*4, p. 20–22*), including, in addition to corn, many vegetables, field crops, flowers, weeds, and large-stemmed grasses.

FIG. 7.—Ear of sweet corn with husks removed to show typical injury to the grain by larvæ of the European corn borer

In the more western areas the corn borers normally pass the winter as full-grown larvæ within their tunnels in the stalks, stubble, or ears of corn, although a great variety of weeds and other plant material may be used for shelter during this period. Seasonal development naturally is dependent upon existing climatic influences, but in a normal season pupation occurs in June. The duration of the pupal period under field conditions averages about two weeks. The moths are in flight during the latter part of June and throughout July and frequently in early August. Eggs are deposited by the moths within a few days after emergence from the pupa (3 to 9 days), and the duration of the life of the moth usually ranges from 10 to 25 days, according to insectary records. The duration of the egg stage is subject to great variation, but usually ranges from 4 to 7 days under cage conditions. The young larvæ begin feeding soon after hatching from the egg, and the majority of them usually reach the last instar in late July or in August. Before the advent of cold weather they become fully mature larvæ. It will be noted therefore that throughout a period of nearly 11 months of each year the corn borer is present

within the host plant in the larval stage and that during most of this period it may be destroyed by utilizing or destroying the host plant.

The seasonal history of the corn borer in New England is characterized by the occurrence of two generations each year. In that section pupation of the overwintering larvæ occurs in late April and in May. The first-brood moths emerge in June, and the eggs deposited by these moths develop into fully grown larvæ in a period ranging from 30 to 40 days. Pupation of these larvæ occurs from mid-July to early August, and the second-brood moths emerge and are in flight during August and early September. The eggs deposited by these moths develop into larvæ which become fully grown before the advent of cold weather. The winter is passed in the larval stage within the stalks, stubble, or ears of corn and in the stems of a great variety of field crops, vegetables, flowers, weeds, and large-stemmed grasses. During certain of the seasons since 1918, when unfavorable climatic conditions prevailed, a portion of the borers in the New England area have developed only a single generation. The duration of the egg, pupal, and adult periods in the New England area are very similar to those mentioned for the Lake Erie region.

FIG. 8.—European corn-borer injury to cobs and grain of dent field corn. The stalks and ear stems from which these ears were removed exhibited severe injury by the insect. The feeding punctures in the husks and the feeding areas on the surface of the ears resulted in the ingress of various rots and molds, which contributed to the damage caused by the corn borer

A more complete discussion of the seasonal cycle and life history of the corn borer, in the different areas of its occurrence, appears in a previous publication (*4, p. 74–90*). A discussion of general seasonal cycle features of the insect will be found in several publications by Babcock (*1, 2, 3*).

DISTRIBUTION OF THE LARVÆ IN THE CORN PLANT

While the corn plant is green and succulent, it may be entered and tunneled by the feeding larvæ at practically any point, but as the plant nears maturity and begins to dry out in its upper portions, or breaks over as a result of injury, the larvæ inhabiting the plant exhibit a tendency to migrate to the lower or more succulent portions.

This habit is of importance in effecting the control of the insect since it results in a large percentage of the larvæ remaining over winter in that portion of the stalk left intact as stubble (fig. 31), where farm practice involves this method of handling the crop. Field investigations have demonstrated that in general 6-inch stubble contained approximately twice as many larvæ as 3-inch stubble and 12-inch stubble contained twice as many larvæ as 6-inch stubble, while similar relative proportions of the total larval population in the stalks before cutting were left in 18-inch and 24-inch stubble (Table 21). As a rule, the number of borers present in stubble of given height, from stalks cut during early November, was approximately three times as great as in stubble from stalks cut during early September (Table 21). It is obvious that in any farm practice involving the cutting of corn, such corn should be cut as early and as low as possible in areas infested by the corn borer, unless subsequent farm operations are such as to provide for the destruction, or the clean plowing under, of the stubble.

FIG. 9.—Broken corn tassel showing injury caused by larvæ of the European corn borer

DISPERSION OF THE CORN BORER BY FLIGHT

The moths are in active flight at night, particularly during the period from sundown to about 11 p. m. During the day they normally seek shelter and remain comparatively inactive under, or among, the foliage of various plants. Experiments have demonstrated (*4, p. 110–114*) that the moths are possessed of strong powers of flight, as was illustrated by the recovery of stained individuals at a maximum distance of 20 miles from the point of liberation. The history of corn-borer infestations in America and their subsequent dispersion indicates that the natural dispersion of the pest by flight, from the various centers of infestation, has been an important factor. The duration of the preoviposition and oviposition period of the females (moths) ranged from 10 to 22 days, in the various groups of moths under observation in the insectary (*4, p. 86–90*), thus indicating an ample provision for dispersion by flight under field conditions when other natural influences were favorable. Although it is realized that the prevention of all natural dispersion by flight of the moths is perhaps beyond the realm of possibility, it is obvious that such dispersion can be greatly minimized by "clean-up" measures designed to reduce the number of corn borers in the areas where they are numerous.

SCOUTING FOR THE CORN BORER

The work of preventing the spread of the European corn borer naturally falls into three divisions: (1) Scouting to locate unknown or newly infested areas, and to determine the boundaries of areas already known to be infested; (2) quarantine work to prevent the transportation of the insect through commerce in infested products; and (3) repressive measures or clean-up work to reduce infestation in densely infested areas or infestations that are especially dangerous because of their locations or that have other characteristics which afford many means of spread.

SCOUTING TO DETERMINE THE LIMITS OF AREAS ALREADY KNOWN TO BE INFESTED

The work of delimiting infestations is most essential, since it is impossible effectively to enforce quarantines without accurate knowledge regarding the exact limits of infestation.

In the case of the corn borer this work is best accomplished by men trained in this particular line of endeavor. They should be able to recognize the insect for which they are searching in all of its stages of development and be familiar with its principal host plants. They should possess, in addition, some knowledge of other insects similar in habits and appearance.

FIG. 10.—Larvæ of the European corn borer, slightly enlarged

Since the scouting season is comparatively short and can not afford permanent employment, it usually is necessary to employ young men. After the candidates are chosen they are given a thorough course of instruction for three or four days, and during this time the final weeding out is accomplished. As the instructors determine their competence, the scouts are made up into crews and assigned to the work as required.

The crews are made up of three or four men, including a foreman, depending upon the nature of the work and the territory they are to cover. Each crew is equipped with a small autotruck, necessary report blanks and forms, a supply of mailing cases, and a supply of gummed paper "arrows." The scouts also are given blue-print maps showing the roads of the townships in which they are to work.

In scouting for the European corn borer it sometimes is necessary to traverse stretches of wood road or areas unsuitable for the existence of the corn borer, and for this reason the autotruck is a great timesaver and is indispensable.

The forms used in recording scouting activities include daily report blanks for listing the number of fields and gardens scouted, number of acres, number of specimens found, host plants on which found, mileage of necessary travel, and other useful information; daily time cards recording the names of foreman and crew, number of hours' work performed, and rate of pay; semimonthly time cards recording the number of hours, by days, for the period, rate of pay, the amount due each member of the crew, and also note of transfers; and sheets for recording collection of specimens, which are sent in triplicate,

with material collected, to the laboratories, giving a complete record of the number of specimens found, locality, and address of the property owner. Final reports are submitted upon the completion of work in a township, giving summaries of the daily reports for that township. Necessary expense vouchers, rules and regulations, subvouchers, record of employees, and accident reports also are furnished.

Special mailing cases, consisting of metal cans contained in metal and substantial cardboard mailing cases, are used for sending in specimens and records of each individual lot found. The specimens are placed alive in the inner can, which is packed loosely with crumpled paper; the can is then wrapped in the record sheets and placed in the mailing case. When packed in this way the specimens invariably arrive in good condition. Upon receipt of specimens at the laboratory, determinations are made, and the foreman of the scouting crew is notified of the results.

The use of gummed-paper arrows is most essential to the proper supervision of efficient scouting work. These arrows are made by cutting diagonally slips of paper about 1½ by 3 inches in size in a manner that forms an end of the slip into an acute point. The foreman places one of these arrows pointing in the direction of his travel in front of his boarding house or hotel (the address of which previously has been forwarded to the office) each morning or upon starting for work. As he proceeds he places one upon a tree, pole, or some other conspicuous place, at every street or road corner he passes, whether a turn is made or not, pointing in the direction he has taken. Upon each arrow he records the date, time of posting the arrow, and his name or initial. These arrows not only aid the general foreman in locating the crews while on their work but also act as checks on the crews. As the time is marked upon each arrow it is very easy for the general foreman to size up the areas covered in a given time and to judge the ability or integrity of the crew. The small amount of time required of the foreman in posting the arrows is amply compensated for by the resultant efficiency.

The blue-print township maps are constructed from enlargements of United States Geological Survey maps and show the section lines, roads, and rivers. All roads outside of the thickly settled sections are lettered, and these letters are used as indices in making reports of the day's work and to designate where work was performed. The maps are a great aid to the scouting crews, as they enable the foreman to lay out the work daily and to make certain that all of the roads of a given township are traversed. The map is marked by the foreman with an X to indicate the location of each cornfield scouted. Where specimens of the corn borer are found the X is inclosed in a circle.

In scouting a township the crews work from that section which is nearest or adjacent to the infested territory and toward the township next assigned to them. Upon starting their next township they continue on along the infested territory or toward the next township assigned. In this manner they are always more familiar with roads which continue through from township to township and with township lines. It has been found advisable, when possible, to assign two or more townships in advance because work in any township ceases as soon as corn borers are found in it.

In scouting for the European corn borer every cornfield and garden is examined in the areas scouted until corn borers are found, when the crew proceeds at once to the next township. The quantity of corn examined in each field depends upon the size of the field and the probability of infestation. For this reason and because the conditions vary in different localities, it is impossible to state the average quantity of corn that a crew should examine in one day. However, it is easy for a general foreman or field superintendent, by inspecting a territory, to estimate the amount of corn that should constitute a day's work for the individual crews.

The general foreman assigned to follow up the scouting crews visits each crew two or more times each week. While the number of

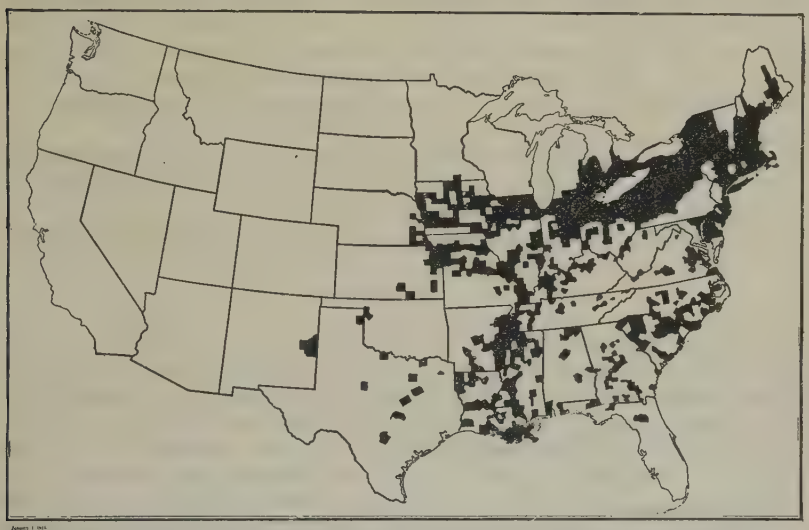

FIG. 11.—Outline map of the United States showing counties that have been scouted for the European corn borer

crews he should be able to supervise depends upon the character of the area to be scouted, 10 or more crews should be easily handled by each general foreman.

The most easily observed indication of an infestation of the European corn borer is the broken tassel of corn; but other parts of the plant also are carefully examined.

SCOUTING IN AREAS DISTANT FROM KNOWN INFESTATIONS

Scouting for the European corn borer has been conducted in all of the States east of the western boundary of Nebraska (fig. 11) except the Dakotas. This work has been distributed in a manner to insure the examination of nearly all sections of each State, except in Minnesota, Wisconsin, and Oklahoma, where little scouting has been performed by Federal inspectors. The localities most likely to be infested are the environs of cities having broom factories that have received broomcorn from the Old World; cities having canning factories that have received seed corn on the cob from eastern

dealers; cities that received products from the infested areas before the quarantine went into effect; cities on waterways on which infested districts are located, and large seaports or distributing centers like New York, Baltimore, Indianapolis, Chicago, and St. Louis.

Practically all of the broom-factory cities east of Kansas have been visited by men who scouted in all of the counties where such factories are located. They also visited each factory and made reports on a printed form, which contain considerable information about the factories, including the quantity of foreign broomcorn received since 1909.

The localities in the vicinity of corn-canning factories in Indiana, Illinois, and Iowa have been scouted, the factories visited, and information obtained relating to the shipment, if any, of seed corn on the cob from eastern dealers. It was learned that many of these factories formerly purchased seed corn on the cob from dealers in Connecticut, New York, and Ohio; but most of them now buy shelled seed in order to avoid danger of introducing the corn borer into their fields.

Scouting also has been conducted around New Orleans and in the vicinity of all of the large seaports on the Atlantic coast and all of the large cities of the Middle West and South.

No corn borers were found in the conduct of this phase of the work.

SCOUTING METHODS

The method used in scouting to determine the possible presence of isolated infestations differs from that adopted in delimiting known infested areas, in that no effort is made to scout small areas intensively. Each scouting crew, consisting usually of two men, follows an itinerary which is prepared before the crew starts on the trip. At each city or town visited the scouts examine cornfields within walking distance from the town or from near-by points reached by electric cars or by suburban trains. In the Western States during the summer of 1922 the men traveled in small autotrucks, and this method was found to be very effective as it enabled them to get out into the country and select fields for scouting.

Several methods of scouting have been used, but the most successful method is to examine several fields of corn closely each day rather than to examine a larger number of fields less thoroughly. The men work regularly up and down the field, walking five rows apart, and in this manner two men can examine from 20 to 30 acres of field corn a day. From one to seven days are spent in a locality, depending on the time available and the probability of the locality's being infested.

The best season to scout for the corn borer is when the corn is in tassel, as at that time the signs of corn-borer activity are more easily seen; but as this period is short and comes at the busy season in quarantine work it is necessary to extend the scouting season long after taselling ceases. In the Western States scouting is continued as late in the fall as the weather will permit, which usually is to about December 1. As most of the cornstalks are left standing in the field in the South, it is possible to do scouting there up to the time when most of the spring plowing is done, and for this reason scouting in the South is conducted during the winter months.

In view of the extensive scouting operations carried on by Federal and State agencies from 1918 to 1924, it would seem that any large infestation of the European corn borer as old as the present known infestations should have been brought to light. However, since foreign broomcorn and other carriers of the corn borer were admitted to the United States within recent years, before quarantine No. 41 became effective, it is apparent that infestations could have started from these shipments as well as from shipments that went out of New England, New York, or Ontario before the quarantines were established. Infestations recently established might escape even the keenest scouting that can be done, so that it is possible that small or light infestations may exist in some of the States now supposed to be uninfested.

SCOUTING IN THE CORN-BELT STATES

Scouting in the Corn-Belt States was started during the fall of 1919 by two crews, one of which visited the canning-factory towns of Indiana, while the other operated in the vicinities of the cities of Chicago, Ill., Milwaukee, Wis., and Dubuque, Iowa.

This work was continued on a larger scale during the summer of 1920 by eight crews. Four of these worked in Ohio, Indiana, Illinois, and Kentucky, scouting along the Ohio River and visiting the broom-factory towns in these States. The other four worked in Iowa, Missouri, Kansas, and Nebraska, scouting along the Missouri River and also visiting the broom-factory towns. Scouting work in these States was discontinued temporarily during the season of 1921 owing to the necessity of using all of the scouts in Ohio and Michigan along Lake Erie; but it was resumed during the summer of 1922 by five crews who worked in Kentucky, Indiana, Illinois, Missouri, and Iowa, scouting along the Ohio, Mississippi, and Missouri Rivers, and also scouting the broom-factory counties of Iowa and Missouri and the canning-factory districts of Indiana, Illinois, and Iowa.

SCOUTING IN THE SOUTHERN STATES

Scouting in the Southern States was started in February, 1921, by four crews who worked in Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Tennessee, Louisiana, and Texas, giving especial attention to the seaports and to the broom-factory cities. This work was continued during the winter of 1922 by four crews in Virginia, North Carolina, South Carolina, and Georgia, and during the winter of 1923 by four crews in Tennessee, Mississippi, Arkansas, and Louisiana.

SCOUTING IN THE EASTERN STATES

Scouting in the Eastern States was started during the winter of 1921 by one crew which scouted in Maryland, particularly in the vicinity of Baltimore. This work was continued during the winter of 1922 by two crews which worked in New Jersey, Delaware, Maryland, and in New York along the Hudson River.

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QUARANTINES ON ACCOUNT OF THE EUROPEAN CORN BORER

QUARANTINE REGULATIONS

Quarantines on account of the European corn borer have been declared by the Federal Horticultural Board of the United States Department of Agriculture, by the Government of the Dominion of Canada, and also by many of the State governments.

THE FEDERAL QUARANTINES

In order to prevent the spread of the European corn borer through the transportation of infested plants or plant products, two quarantines have been promulgated by the Secretary of Agriculture. The first of these, known as quarantine No. 41, is a foreign quarantine, established with the intention of affording protection against further introductions of the corn borer from foreign countries. The second is quarantine No. 43, a domestic quarantine, established for the purpose of preventing the spread of the corn borer from infested areas within the United States to points outside those areas, through the interstate commerce in infested farm and garden products.

THE CANADIAN QUARANTINES

The Government of the Dominion of Canada has in force two quarantines on account of the European corn borer. The foreign quarantine has for its purpose the prevention of further introduction of the corn borer into Canada from foreign countries. The domestic quarantine is for the purpose of preventing the spread of the corn borer from infested districts in the Province of Ontario to points outside of those districts.

METHOD OF ADMINISTERING THE FEDERAL QUARANTINES

PUBLICITY GIVEN QUARANTINE RESTRICTIONS

All possible publicity is given to quarantine matters. New quarantines are promulgated and changes are made in the quarantine regulations only after public hearings before the Federal Horticultural Board, which are advertised by public notice and by press notices furnished to the newspapers and to the agricultural and horticultural press. When a notice of quarantine is issued or when changes are made in the quarantine rules and regulations, notice is given in writing to the transportation companies doing business in or through the State or States in which the infested areas are located and by publication in newspapers selected by the Secretary of Agriculture within the State in which the affected areas are located.

Printed copies of the quarantine notices and large "Warning" posters (figs 12 and 13) are mailed to wholesale produce dealers, seedsmen, dealers in straw, those using straw for packing purposes, truckers, growers, florists, nurserymen, funeral directors, and transportation companies throughout the infested areas. These "Warning" posters are also displayed at all roadside produce stands, produce markets, railroad stations, steamship wharves, express offices, and other public places throughout the infested areas, to caution the public against attempting to transport quarantined products from points within infested areas to points outside such areas.

U. S. DEPARTMENT OF AGRICULTURE
FEDERAL HORTICULTURAL BOARD
In Cooperation With
BUREAU OF ENTOMOLOGY

EUROPEAN CORN BORER QUARANTINE

EFFECTIVE NOVEMBER 23, 1926

ENFORCED IN COOPERATION WITH STATE QUARANTINES

WARNING

Federal and State Regulations Prohibit the transportation of CORN and BROOMCORN (including all parts of the stalk), all SHELLED CORN, SEED OF BROOMCORN, SORGHUMS and SUDAN GRASS, from quarantined areas in INDIANA, MICHIGAN, OHIO, WEST VIRGINIA, PENNSYLVANIA, NEW YORK, and VERMONT, to points outside the area quarantined, on account of the EUROPEAN CORN BORER, unless accompanied by a CERTIFICATE of Inspection.

CITIES, TOWNSHIPS, AND COUNTIES IN THE QUARANTINED AREA

INDIANA

COUNTIES OF DEKALB and STEUBEN, and all townships and all other political subdivisions thereof.

TOWNSHIPS of Adams, Cedar Creek, Eel River, Jackson, Jefferson, Maumee, Milan, Perry, St. Joseph, Scipio, Springfield, Washington, and Wayne, in ALLEN COUNTY; Bloomfield, Clay, Clear Creek, Greenfield, Johnson, Lima, Milford, and Springfield, in LAGRANGE COUNTY; Albion, Allen, Elkhart, Green, Jefferson, Noble, Orange, Swan, Wayne, and York, in NOBLE COUNTY; Smith and Thorn Creek, in WHITLEY COUNTY.

MICHIGAN

COUNTIES OF BAY, BRANCH, CALHOUN, GENESEE, HILLSDALE, HURON, INGHAM, JACKSON, LAPEER, LENAWEE, LIVINGSTON, MACOMB, MONROE, OAKLAND, SANILAC, SAGINAW, SHIAWASSEE, ST. CLAIR, TUSCOLA, WASHTENAW, and WAYNE, and all townships and all other political subdivisions thereof.

TOWNSHIPS of Brady, Charleston, Climax, Comstock, Pavilion, Portage, Richland, Ross, Schoolcraft, and Wakeshma, in KALAMAZOO COUNTY; Burr Oak, Colon, Fawnriver, and Lake, in ST. JOSEPH COUNTY.

OHIO

COUNTIES OF ASHLAND, ASHTABULA, CARROLL, COLUMBIANA, CRAWFORD, CUYAHOGA, DEFIANCE, ERIE, FULTON, GEAUGA, HANCOCK, HARRISON, HENRY, HURON, JEFFERSON, LAKE, LORAIN, LUCAS, MAHONING, MEDINA, OTTAWA, PAULDING, PORTAGE, PUTNAM, RICHLAND, SANDUSKY, SENECA, STARK, SUMMIT, TRUMBULL, WAYNE, WILLIAMS, WOOD, AND WYANDOT, and all townships and all other political subdivisions thereof.

TOWNSHIPS of Bath, Jackson, Monroe, Perry, and Richland, in ALLEN COUNTY; Blanchard, Cessna, Goshen, Jackson, Liberty, Pleasant, and Washington, in HARDIN COUNTY; Berlin, Hardy, Knox, Mechanic, Monroe, Paint, Prairie, Ripley, Salt Creek, Walnut Creek, and Washington, in HOLMES COUNTY; Berlin, Middlebury, and Pike, in KNOX COUNTY; Big Island, Claridon, Grand, Marion, Montgomery, Prairie, Salt Rock, Scott, and Tully, in MARION COUNTY; Canaan, Cardington, Congress, Franklin, Gilead, North Bloomfield, Perry, Troy, and Washington, in MORROW COUNTY; Dover, Fairfield, Franklin, Goshen, Lawrence, Mill, Sandy, Sugar Creek, Uhrichville, Warren, and Wayne, in TUSCARAWAS COUNTY; Hoaglin, Jackson, Ridge, and Washington, in VAN WERT COUNTY.

WEST VIRGINIA

COUNTIES OF BROOKE, HANCOCK, AND OHIO, and all townships and all other political subdivisions thereof.

PENNSYLVANIA

COUNTIES OF ALLEGHENY, ARMSTRONG, BEAVER, BLAIR, BRADFORD, BUTLER, CAMBRIA, CAMERON, CENTER, CLARION, CLEARFIELD, CLINTON, CRAWFORD, ELK, ERIE, FOREST, INDIANA, JEFFERSON, LAWRENCE, LYCOMING, McKEAN, MERCER, POTTER, SULLIVAN, SUSQUEHANNA, TIOGA, VENANGO, WARREN, WASHINGTON, AND WESTMORELAND, and all townships and all other political subdivisions thereof.

TOWNSHIP of Jackson, in HUNTINGTON COUNTY.

NEW YORK

COUNTIES OF ALBANY, ALLEGANY, BROOME, CATTARAUGUS, CAYUGA, CHAUTAUQUA, CHEMUNG, CHENANGO, CLINTON, COLUMBIA, CORTLAND, ERIE, ESSEX, FRANKLIN, FULTON, GENESEE, GREENE, HAMILTON, HERKIMER, JEFFERSON, LEWIS, LIVINGSTON, MADISON, MONROE, MONTGOMERY, NIAGARA, ONEIDA, ONONDAGA, ONTARIO, ORLEANS, OSWEGO, OTSEGO, RENSSELAER, ST. LAWRENCE, SARATOGA, SCHENECTADY, SCHOHARIE, SCHUYLER, SENECA, STEUBEN, TIOGA, TOMPKINS, WARREN, WASHINGTON, WAYNE, WYOMING, AND YATES, and all townships and all other political subdivisions thereof. ALSO COUNTIES OF KING'S, QUEEN'S, RICHMOND, NASSAU.

VERMONT

TOWNSHIPS of Bennington and Pownal, in BENNINGTON COUNTY.

NEW JERSEY

CITIES OF BAYONNE AND JERSEY CITY.

CORN ON COB WILL NOT BE CERTIFIED FOR SHIPMENT

Maximum penalties of imprisonment for one year and a fine of $500 are provided by law for violations of this quarantine.

For inspection apply to:

For further information apply to
L. H. WORTHLEY,
Administrator in Corn Borer Control.
2336 East 22d St., Cleveland, Ohio.

FIG. 12.—Warning poster placed in public places in the infested areas to advise the public against shipping quarantined products

U. S. DEPARTMENT OF AGRICULTURE
FEDERAL HORTICULTURAL BOARD
In Cooperation With
BUREAU OF ENTOMOLOGY

EUROPEAN CORN BORER QUARANTINE

EFFECTIVE NOVEMBER 23, 1926

ENFORCED IN COOPERATION WITH STATE QUARANTINES

WARNING

Federal and State Regulations prohibit the transportation of the following CUT FLOWERS, PLANTS, and FARM PRODUCTS from infested areas in MAINE, NEW HAMPSHIRE, MASSACHUSETTS, and RHODE ISLAND to points outside the area quarantined on account of the EUROPEAN CORN BORER, unless accompanied by a Permit or Certificate of Inspection:

CUT FLOWERS AND PLANTS

Chrysanthemum Cosmos Hollyhock
Dahlia Aster Zinnia Gladiolus

FARM PRODUCTS

Corn Broomcorn Celery Beets with tops Rhubarb
All Sorghums Shelled Corn and Seed Green Beans in
Sudan Grass of Broomcorn the pod
Oat and Rye Straw as such or when used as packing

CITIES AND TOWNS IN THE QUARANTINED AREA

MAINE

Acton, Alfred, Baldwin, Berwick, Biddeford, Buxton, Cape Elizabeth, Cornish, Cumberland, Dayton, Eliot, Falmouth, Freeport, Gorham, Hollis, Kennebunk, Kennebunkport, Kittery, Lebanon, Limerick, Limington, Lyman, Newfield, North Berwick, Old Orchard, Parsonfield, Porter, Portland, Saco, Sanford, Scarboro, Sebago, Shapleigh, South Berwick, South Portland, Standish, Waterboro, Wells, Westbrook, Windham, Yarmouth, York

NEW HAMPSHIRE

Alexandria, Allenstown, Alton, Amherst, Andover, Antrim, Ashland, Atkinson, Auburn, Barnstead, Barrington, Bedford, Belmont, Bennington, Boscawen, Bow, Bradford, Brentwood, Bridgewater, Bristol, Brookfield, Brookline, Campton, Canaan, Candia, Canterbury, Center Harbor, Chester, Chichester, Concord, Danbury, Danville, Deerfield, Deering, Derry, Dover, Dumbarton, Durham, East Kingston, Effingham, Epping, Epsom, Exeter, Farmington, Francestown, Franklin, Fremont, Gilford, Gilmanton, Goffstown, Greenfield, Greenland, Greenville, Croton, Hampstead, Hampton, Hampton Falls, Hancock, Hebron, Henniker, Hill, Hillsboro, Holderness, Hollis, Hooksett, Hopkinton, Hudson, Kensington, Kingston, Laconia, Lee, Litchfield, Londonderry, Loudon, Lyndeboro, Madbury, Manchester, Mason, Meredith, Merrimac, Middleton, Milford, Milton, Moultonboro, Mont Vernon, Nashua, New Boston, Newbury, New Castle, New Durham, New Hampton, Newington, New Ipswich, New London, Newmarket, Newton, Northfield, North Hampton, Northwood, Nottingham, Orange, Pelham, Pembroke, Peterboro, Pittsfield, Plaistow, Plymouth, Portsmouth, Raymond, Rochester, Rollinsford, Rye, Salem, Salisbury, Sanbornton, Sandown, Seabrook, Sharon, Somersworth, South Hampton, South Newmarket, Stoddard, Strafford, Stratham, Sutton, Temple, Tilton, Tuftonboro, Wakefield, Warner, Weare, Webster, Wilmot, Wilton, Windham, Windsor, Wolfeboro

MASSACHUSETTS

Abington, Acton, Acushnet, Amesbury, Andover, Arlington, Ashburnham, Ashby, Ashland, Attleboro, Avon, Ayer, Barnstable, Bedford, Bellingham, Belmont, Berkley, Berlin, Beverly, Billerica, Blackstone, Bolton, Boston, Bourne, Boxboro, Boxford, Boylston, Braintree, Brewster, Bridgewater, Brockton, Brookline, Burlington, Cambridge, Canton, Carlisle, Carver, Chatham, Chelmsford, Chelsea, Chilmark, Clinton, Cohasset, Concord, Cuttyhunk Island, Danvers, Dartmouth, Dedham, Dennis, Dighton, Douglas, Dover, Dracut, Dunstable, Duxbury, East Bridgewater, Eastham, Easton, Edgartown, Essex, Everett, Fairhaven, Fall River, Falmouth, Fitchburg, Foxboro, Framingham, Franklin, Freetown, Gardner, Gayhead, Georgetown, Gloucester, Grafton, Groton, Groveland, Halifax, Hamilton, Hanover, Hanson, Harvard, Harwich, Haverhill, Hingham, Holbrook, Holden, Holliston, Hopedale, Hopkinton, Hubbardston, Hudson, Hull, Ipswich, Kingston, Lakeville, Lancaster, Lawrence, Leominster, Lexington, Lincoln, Littleton, Lowell, Lunenburg, Lynn, Lynnfield, Malden, Manchester, Mansfield, Marblehead, Marion, Marlboro, Marshfield, Marthas Vineyard, Mashpee, Mattapoisett, Maynard, Medfield, Medford, Medway, Melrose, Mendon, Merrimac, Methuen, Middleboro, Middleton, Milford, Millbury, Millis, Millville, Milton, Nahant, Nantucket, Naushon Island, Nashawena Island, Natick, Needham, New Bedford, Newbury, Newburyport, Newton, Nonamesset Island, Norfolk, North Andover, North Attleboro, Northboro, Northbridge, North Reading, Norton, Norwell, Norwood, Oak Bluffs, Orleans, Pasque Island, Peabody, Pembroke, Penikese Island, Pepperell, Plainville, Plymouth, Plympton, Princeton, Provincetown, Quincy, Randolph, Raynham, Reading, Rehoboth, Revere, Rochester, Rockland, Rockport, Rowley, Rutland, Salem, Salisbury, Sandwich, Saugus, Scituate, Seekonk, Sharon, Sherborn, Shirley, Shrewsbury, Somerset, Somerville, Southboro, Sterling, Stoneham, Stoughton, Stow, Sudbury, Sutton, Swampscott, Swansea, Taunton, Tewksbury, Tisbury, Topsfield, Townsend, Truro, Tyngsboro, Upton, Uxbridge, Wakefield, Walpole, Waltham, Wareham, Watertown, Wayland, Webster, Wellesley, Wellfleet, Wenham, Westboro, West Boylston, West Bridgewater, Westford, Westminster, West Newbury, West Tisbury, Weston, Westport, Westwood, Weymouth, Whitman, Wilmington, Winchester, Winthrop, Woburn, Worcester, Wrentham, Yarmouth

RHODE ISLAND

Barrington, Bristol, Central Falls, Coventry, Charlestown, Cranston, Cumberland, East Greenwich, East Providence, Jamestown, Johnston, Lincoln, Little Compton, Middletown, Narragansett, Newport, New Shoreham, North Kingston, North Providence, North Smithfield, Pawtucket, Portsmouth, Providence, Smithfield, South Kingston, Tiverton, Westerly, Warren, Warwick, Woonsocket

CONNECTICUT: East Lyme, Groton, New London, Stonington, Waterford.

In case of corn, broomcorn, shelled corn, and seed of broomcorn, sorghum and Sudan grass, cut flowers or entire plants of chrysanthemum, aster, cosmos, zinnia, hollyhock, and cut flowers or entire plants of gladiolus and dahlia, except the bulbs thereof, without stems, this quarantine and regulations shall apply throughout the year.

In the case of all other products listed above, the quarantine applies for the period between June 1 and December 31.

CORN ON COB WILL NOT BE CERTIFIED FOR SHIPMENT

Maximum penalties of imprisonment for one year and a fine of $500 are provided by law for violations of this quarantine.

For inspection apply to:

For further information apply to
L. H. WORTHLEY,
Administrator in Corn Borer Control.

FIG. 13.—Warning poster placed in public places in the infested towns of New England to advise the public against shipping quarantined products

On all main highways leading out of infested areas large banners (fig. 14) are displayed at the quarantine lines warning automobilists and others against carrying quarantined products across such lines.

INSPECTION AND CERTIFICATION

The methods of inspection and certification for all products under quarantine, grown within the infested areas, have been changed from

WARNING
EUROPEAN CORN BORER QUARANTINE
DO NOT CARRY GREEN CORN BEYOND THIS POINT
FEDERAL AND STATE LAWS PROVIDE HEAVY PENALTY FOR VIOLATIONS.

FIG. 14.--Warning banner at the quarantine line on one of the roads leading from the infested area

season to season to adapt them to developing conditions. This work is all conducted in cooperation with the Federal Horticultural Board. The inspection work began March 29, 1920, and consisted of market inspection of cut flowers and flowering plants, wash-room inspection of celery, and field inspection of bunch beets, spinach, rhubarb, and beans. During the season of 1921 bunch beets were also inspected in the wash rooms.

Under this system large quantities of products were inspected and certified which did not move outside the infested areas. For the sake of economy, therefore, at the beginning of the season of 1922 the field and wash-room inspections of vegetables were almost entirely

abandoned and inspections in the wholesale markets were substituted, except where growers proposed to ship direct to points outside of the infested areas. If upon inspection the products were found free from infestation by the European corn borer, certificates were granted to the extent of the shipment, each package being covered by a separate certificate. Market inspection of all products was found to be so successful during the season of 1922 that this method is being continued.

Field Inspection of Vegetables

In the process of field inspection, the crews carefully examine the growing plants in the fields and certificates are withheld where the corn borer is found, either on any crop plant or on any weed in the field. Where corn borers are not found, certificates are issued covering shipments from that particular field for a period of five days, after which it must be reinspected in case additional shipments are to be made.

Table 1 shows the number of certificates issued as a result of field inspections of spinach, beans, beets, and rhubarb in New England during the season of 1921, together with the number of fields of these plants found to be infested and for which certificates were refused. The 41 beet fields found to be infested were inspected early in the season, and as corn borers could be found in practically all fields, washroom inspection of beets was chosen as the better method in this case. The number of certificates issued for celery and beets with tops is given in Table 2, which includes the small number issued after field inspection as well as the larger number issued during washroom inspection.

Table 3 shows the number of certificates issued during field inspection of celery, beets, spinach, beans, and rhubarb in the territory surrounding Albany, N. Y., and Table 4 shows the number of certificates issued after field inspection of vegetables in western New York during the season of 1921. No corn borers were found in these New York inspections, and at the end of the season of 1921 the quarantine was revised so as to eliminate vegetables other than corn from the quarantine in the more western areas, including the entire State of New York.

Table 1.—*Number of certificates issued in field inspection and number of fields infested, New England, June 1 to December 31, 1921*

State and town	Certificates issued for—			Infested fields found			
	Spinach [1]	Beans [1]	Rhubarb [1]	Spinach	Beets	Beans	Rhubarb
Massachusetts:							
Arlington	730	2,523		15	13	5	1
Belmont	300	850		2	3	2	1
Braintree		100				1	
Burlington	6,200	1,240			1		
Concord	250	805	100				
Danvers				1			
Lexington	1,732			2	3		2
Lynn		250			2		
Melrose	1,050			1			
Methuen					2		
Needham		250	650				
Newton	385	830			1		
Revere	6,945	525			1	1	

[1] 1 certificate for each bushel box.

TABLE 1.—*Number of certificates issued in field inspection and number of fields infested, New England, June 1 to December 31, 1921*—Continued

State and town	Certificates issued for—			Infested fields found			
	Spinach	Beans	Rhubarb	Spinach	Beets	Beans	Rhubarb
Massachusetts—Continued.							
Watertown	1,900	3,120			3	1	
Waltham		150					
Wayland	150	100					
Winchester	4,500		450		2	2	
Woburn	8,023	1,360		9	5	1	
Beverly	550						
Lincoln		60					
Newbury		100			1		
Sherborn		90					
Sudbury		150					
Cambridge		50					
Lowell	150						
Ipswich		100					
Brookline					2	1	
Greenbush				1			1
Saugus							2
Weymouth					2		
New Hampshire:							
Greenland	540		15				
Portsmouth	25		10				
Total	33,430	12,653	1,225	31	41	14	7

Grand totals: 47,308 certificate tags issued; 93 infested fields found for which no tags were issued.

TABLE 2.—*Number of certificates issued and number of corn borers found in washroom inspection of celery and beets with tops, infested towns of New England, June 1 to December 31, 1921*

State and town	Certificates for celery [1]	Corn borers found in celery	Certificates for beets [1]	Corn borers found in beets
Massachusetts:				
Arlington	53,389	2,285	2,532	1,381
Belmont	17,959	248	360	
Braintree	224			
Burlington	2,731	5	71	13
Concord	1,289		450	
Danvers			241	156
Lexington	1,438		168	6
Lynn			57	10
Melrose	1,332	33		
Methuen	43		242	5
Newton	109	4	159	7
Peabody			100	
Revere	8,548	267	519	194
Watertown	8,574	128	3,328	885
Wayland			300	
Winchester	7,349	588	1,443	292
Woburn	10,906	59	2,877	398
Newbury			100	
Reading	292	5		
Sherborn			90	
Sudbury			100	
Cambridge	719	118		
Ipswich			100	
New Bedford			50	
New Hampshire:				
Greenland			50	
Total	114,902	3,740	13,337	3,347

Grand totals: 128,239 certificates issued; 7,087 corn borers found.

[1] 1 certificate for each bushel box.

TABLE 3.—*Number of certificates issued in field inspections in the eastern New York area, June 1 to December 31, 1921*

Town	Certificates issued for—				
	Celery	Beets	Spinach	Beans	Rhubarb
Albany	2,536	1,686	889	695	35
Broadalbin		175			
Colonie	4,357	2,623	765	4,617	160
Charlton		40		40	
East Greenbush	50			1,335	
Gloversville		135	65	65	65
Guilderland				65	
Niskayuna	50	150		170	
Saratoga	20				
Schenectady		229		450	
Scotia		95		50	
Waterford				50	
Watervliet		90	60	215	
Total	7,013	5,203	1,779	7,752	260

Grand total, 22,007 certificates.

TABLE 4.—*Number of certificates issued in field inspections in the western New York area, June 1 to December 31, 1921*

Town	For celery	For beets	For spinach	For beans	For dahlias	For asters	For gladioluses	For cosmos	For zinnias	For chrysanthemums
Amherst										350
Aurora				444						
Boston				1						
Brant				6,260						
Cheektowaga										355
Dunkirk		281	50	49						
East Hamburg	50	665	75	3,838		90				
Eden		85		131			25			
Ellery							25			
Evans				1,954	25	25	275			25
Hamburg	665	295		485	245	85	325	10	80	10
Hanover		20		191						100
North Collins		44		1,890						
Portland							29			
Sheridan		753	100	230						
Sherman				5						
Westfield		233		109	50	190	472	25	25	50
West Seneca	1,400	912	474	75						250
Total	2,115	3,288	699	15,722	320	390	1,151	35	105	1,140

Grand total, 24,965 certificates.

A total of 94,280 certificates were issued after field inspection of vegetables in the New York and Massachusetts areas from June 1 to December 31, 1921.

During the season of 1922 field inspection of vegetables with the exception of spinach was practically discontinued in the New England areas. Spinach was inspected in the field and not in the market, and 53 infested fields were inspected, in which 174 borers were found. When corn borers were discovered in a field the inspection was discontinued, so that the number of borers actually collected in a given field does not indicate the number actually present. Twenty uninfested fields were inspected, and 2,541 boxes of spinach were certified from such fields.

Wash-room Inspection of Vegetables

In wash-room inspection of beets and celery, immediately after they have been gathered from the field, the plants are examined by inspectors, the infested plants are removed, and the uninfested plants are returned to the packers, who wash and pack them in standard bushel boxes. After the vegetables have been packed, a certificate is placed on each box by the inspector. Wash-room inspections are made only in the infested area of Massachusetts, where the market gardeners practice washing and packing of celery, bunch beets, and spinach, as previously mentioned.

Wash-room inspection of celery began with the packing season of 1920, and beets were thus inspected during the season of 1921. A total of 128,239 certificate tags were issued in such inspections of beets and celery from June 1 to December 31, 1921.

The number of corn borers found and the number of boxes of celery and beets examined during these inspections in each town for the season of 1921 are given in Table 2.

During the season of 1922, wash-room inspections were made only when the grower proposed shipping products direct to points outside the infested area without their passing through the Boston market. A total of 1,988 boxes of beets with tops were thus inspected, and 2,523 corn borers and 727 egg masses were found in these beets. Only 264 boxes of market celery were inspected, in which 34 borers were found, and 61,000 seedling celery plants, which were uninfested. There were 130 boxes of rhubarb inspected during the season of 1922.

Market Inspection of Vegetables

The terms of the quarantine are enforced also by inspectors employed by the Bureau of Entomology in the wholesale vegetable and flower markets. During the period in which the quarantine is effective, an inspection station is maintained in the center of the wholesale vegetable districts and in the flower markets in the infested areas. Telephone service is provided, and inspectors on duty at these places from 6 a. m. to 6 p. m. are subject to the call of merchants, forwarding agents, or private individuals who wish to send quarantined products outside the infested areas. These inspectors are provided with badges of authority issued by the Bureau of Entomology and the Federal Horticultural Board and with supplies of the necessary permits and certificates authorizing shipments.

The work in the markets includes the inspection of such vegetables, cut flowers, and flowering plants, grown within the infested area, as are permitted to move on certificates of inspection, and the issuing of permits for the reshipment of such products as are known to have been grown outside the infested area.

During the seasons of 1924 to 1926, inclusive, market inspection of the farm products named in the quarantine was carried on from the markets at Boston and Worcester, Mass., Portland, Me., and Providence, R. I., and this method of inspection was found to be practical and economical. The inspectors opened the boxes of beans, beets, celery, and rhubarb, examined the contents, and removed and disposed of all infested products, after which the boxes were repacked and certified for shipment. Data on the number of boxes inspected

and the destination of the shipments are given in Table 5. Table 6 gives the number of specimens found in the products inspected in New England from 1920 to 1926, inclusive.

TABLE 5.—*Farm products inspected and certified for shipment to points outside of the New England area quarantined on account of the European corn borer, from June 1 to December 31 in 1924, 1925, and 1926*

Destination	Beans			Beets			Celery					Rhubarb			
	1924	1925	1926	1924	1925	1926	1924	1925		1926		1924	1925	1926	
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Plants*	*Bu.*	*Plants*	*Bu.*	*Bu.*	*Bu.*	*Plants*	*Bu.*
Connecticut	221	198	942	543	427	290	1,302	400	1,168	192	548	1	1		21
Dist. Columbia									4						
Florida												1			
Georgia						2					4				
Illinois			1												
Maine	2,029	4,557	4,424	2,094	3,083	3,060	4,409	2,115	4,087	1,001	3,749	86	87		148
Maryland									5						
Massachusetts	956	890	1,714	568	470	559	6,810	1,550	4,085	510	2,580	82	65		58
Michigan							500	1,000							
Missouri								24							
New Hampshire	1,007	1,513	1,480	853	1,098	860	3,230	1,224	1,956	1,264	1,518	39	31		42
New Jersey							1		5	2,000					
New York	452	60	1,118	44	13	20	1,915	1,262	115		90	7	27	160	31
North Carolina	1		1								6				
Ohio							1		1						
Pennsylvania										1,500					
Rhode Island	785	542	420	702	559	440	353		1,081		650	2	3		2
Vermont	372	754	910	593	738	605	1,793	1,702	1,699	775	1,638	20	11		7
West Virginia							1								
Canada	97	326	203	109	287	250	18		52		39	64			452
Total	5,920	8,840	11,213	5,506	6,675	6,086	20,333	9,277	14,258	7,442	10,822	302	225	160	761

TABLE 6.—*Specimens of the European corn borer found during inspection of quarantined products throughout the period 1920 to 1926, inclusive*

Year	Number of specimens [1]	Year	Number of specimens [1]	Year	Number of specimens [1]
1920	2,698	1923	866	1926	197
1921	7,027	1924	575		
1922	14,210	1925	209	Total	25,782

[1] Includes egg clusters, larvæ, and pupæ.

INSPECTION OF CUT FLOWERS AND FLOWERING PLANTS

Large quantities of cut flowers and plants grown in the infested areas are shipped to outside points. Inspections are made upon request in the wholesale flower markets, at the florists' shops, and at the growers' establishments when direct shipment is to be made. Each flower or plant is examined before it is packed, and a certificate is issued for each shipment after it is packed.

During the seasons of 1924 to 1926, inclusive, cut flowers were inspected and certified for shipment from the flower market and flower shops in Boston, Worcester, Portland, and Providence. Asters, chrysanthemums, and gladioluses were the chief plants inspected. Many of the flower growers in eastern New England ship large quantities of cut flowers and plants direct to customers located outside of the infested area. The details concerning these inspections are given in Tables 7 and 8.

TABLE 7.—*Cut flowers certified for shipment to points outside of the New England area quarantined on account of the European corn borer from June 1 to December 31 in 1924, 1925, and 1926*

Destination	Aster			Chrysanthemum			Cosmos			Dahlia		
	1924	1925	1926	1924	1925	1926	1924	1925	1926	1924	1925	1926
California	35			8						55	62	1
Colorado		6			42					28	12	
Connecticut	18,385	12,871	12,473	22,135	21,008	28,811		72	200	493	273	347
Delaware				8		12				34	58	8
District of Columbia	8,400	12		4,206	1,414	496				72	36	
Florida		24		4	9	258				6		
Georgia		1		16							8	
Illinois	924	131	12	35	236	252				49	19	7
Indiana	12	96	5	2		212				32	200	31
Iowa				90	19					14	2	
Kansas			18							13	6	
Kentucky	12	10		6	15					67	94	17
Louisiana					12							
Maine	55,757	24,032	24,359	46,139	42,784	83,599	204	190	327	166	162	149
Maryland	26	132	8	112	615					394	183	101
Massachusetts	15,111	11,043	12,848	34,268	32,601	24,442	162		48	1,607	1,942	956
Michigan	32	57	12	258	82	27				35	11	
Minnesota	1			6	26					18	12	
Mississippi										7		
Missouri		268		8	36					74	11	2
Nebraska	2			16	11						22	
New Hampshire	16,024	16,016	17,750	17,386	26,236	22,855	336	157	12	147	78	109
New Jersey	393	715	15	8,645	3,063	429		100		785	675	95
New York	103,214	114,546	252,652	346,936	263,555	521,368	294	110	1,018	2,492	1,643	190
North Carolina			100	15	12	12				14	15	
Ohio	36	4,006	500	7,236	9,620	2,288				228	202	39
Oklahoma					12						13	
Oregon	2	2				1				3		2
Pennsylvania	3,045	811	81	12,667	6,300	2,870				790	582	138
Rhode Island	115	292	63	2,548	989	354				148	43	51
South Carolina					50						8	
Tennessee					8					8	20	4
Texas				12	6							
Utah											15	
Vermont	16,157	17,044	19,654	13,468	25,432	33,359	24		600	62	17	26
Virginia	221	11	3	150	71	46				154	76	49
Washington	36			42						7	16	4
West Virginia	4	2		14	12					119	237	35
Wisconsin	6	12			48					24	14	18
Canada	2,217	642	2,515	6,211	1,196	1,016				14	175	74
China	1			6								
Cuba												
England												14
Europe (Continental)			24									
Total	240,168	202,782	343,092	522,653	435,520	722,707	1,020	629	2,205	8,159	6,942	2,467

Destination	Gladiolus			Hollyhock			Zinnia			Totals			Grand total
	1924	1925	1926	1924	1925	1926	1924	1925	1926	1924	1925	1926	
Calif				6	13					104	75	1	180
Colo					4					28	64		92
Conn	14,566	18,102	16,101	267	121	76	24	212	915	55,870	52,659	58,923	167,452
Del										42	58	20	120
D. C	14,818	15,404	109	12	12		12			27,520	16,878	605	45,003
Fla		30	18			12			3	10	63	291	364
Ga				1						17	9		26
Ill	73	60	72	1	30					1,082	476	343	1,901
Ind		145		1				26		47	467	248	762
Iowa	24	36			11					128	68		196
Kans										13	6	18	37
Ky		50	120	6		12				91	169	149	409
La								12			24		24
Me	20,810	20,028	23,949	255	486	24	78	247	412	123,409	87,929	132,819	344,157
Md	48	120	13		17					580	1,067	122	1,769
Mass	18,562	7,475	14,704	166	254	38	148	47	149	70,024	53,362	53,185	176,571
Mich	156	36	18	48	2	12	17	48		546	236	69	851
Minn	48	26		31		50				104	64	50	218
Miss				1						8			8
Mo		50		1	17			100		83	482	2	567
Nebr										18	33		51
N. H	7,296	10,884	14,316	225	134	6	784	469	139	42,198	53,974	55,187	151,359

TABLE 7.—*Cut flowers certified for shipment to points outside of the New England area quarantined on account of the European corn borer from June 1 to December 31 in 1924, 1925, and 1926*—Continued

Destination	Gladiolus			Hollyhock			Zinnia			Totals			Grand total
	1924	1925	1926	1924	1925	1926	1924	1925	1926	1924	1925	1926	
N. J.	356	994	151	18	119			31	3	10,197	5,697	693	16,587
N. Y.	660,503	667,348	1,015,429	76	189	30	136	526	2,941	1,113,651	1,047,917	1,793,628	3,955,196
N. C.	24	29								53	56	112	221
Ohio	158	48	228	24	26					7,682	13,902	3,055	24,639
Okla.											25		25
Oreg.								7		5	9	3	17
Pa.	12,641	1,370	1,255	30	66	6			355	29,173	9,129	4,705	43,007
R. I.	726	3,823	7,429	40	36					3,577	5,183	7,897	16,657
S. C.	300									300	58		358
Tenn.										8	28	4	40
Tex.				1						13	6		19
Utah											15		15
Vt.	5,822	7,553	1,850	197	245	8		30	24	35,730	50,321	55,521	141,572
Va.	126	87	60	124	16					775	261	158	1,194
Wash.										85	16	4	105
W. Va.										137	251	35	423
Wis.			12		1					30	75	30	135
Canada	4,058	1,921	1,627		1				40	12,500	3,935	5,272	21,707
China										7			7
Cuba	3,000									3,000			3,000
England	85		36							85		50	135
Europe (Continental)			24						12			60	60
Total	764,200	755,619	1,097,521	1,531	1,800	274	1,199	1,755	4,993	1,538,930	1,405,047	2,173,259	5,117,236

TABLE 8.—*Flower plants inspected and certified for shipment to points outside the New England area quarantined on account of the European corn borer, January 1 to December 31, 1926* [1]

	Aster	Chrysanthemum	Cosmos	Dahlia	Hollyhock	Zinnia	Total
Alabama				18	6		24
California				52			52
Colorado		14		10	12		36
Connecticut	395	846	36	234	212		1,723
Delaware				78	101		179
District of Columbia				47			47
Florida	6	4					10
Georgia				23			23
Illinois		110		8	9		127
Indiana				68	12		80
Iowa				8			8
Kansas		10					10
Kentucky				80			80
Maine	674	287	102	78	50	137	1,328
Maryland				140			140
Massachusetts	55	218	6	157	84	36	556
Michigan	6			91			97
Missouri				1			1
Nebraska				48			48
New Hampshire	504	199	422	44	83	464	1,716
New Jersey	19	396		524	56		995
New York	600	4,042	59	723	116	54	5,594
North Carolina	36			94			130
Ohio	17	43		174	18		252
Oklahoma				4			4
Oregon	2			4			6
Pennsylvania	18	114		627	24		783
Rhode Island		114		3	62		179
Tennessee				52			52
Vermont	70	3,576	6	15	113	18	3,798
Virginia	12	62		96			170
Washington				15			15
West Virginia	4	20		232	6		262
Wisconsin				46	100		146
Canada	100		100	367		100	664
Total	2,518	10,055	731	4,161	1,064	809	19,338

[1] The unit is a single plant.

ISSUING PERMITS FOR THE RESHIPMENT OF PRODUCTS GROWN OUTSIDE THE INFESTED AREA

The method pursued in issuing permits for reshipment of products may be briefly outlined as follows: A commission merchant receives an order for products covered by the quarantine, to be shipped to a point outside the infested area. The shipment having originated at a point outside the infested area must, upon arrival within the quarantined area, be covered by a permit authorizing the railroads and express companies to accept it for reshipment. The person interested notifies the inspection station by telephone, and the inspector immediately proceeds to the place where the products are located, satisfies himself that they originated outside the infested area by inspecting the waybill or other documentary evidence presented, and issues the necessary permits.

These permits are printed on paper of a durable grade, and bear the facsimile signature of the officer issuing the permit. They are securely fastened to the package in the presence of the inspector.

During the season of 1923 much green corn on the ear, originating outside the infested area in New York, was shipped to the Albany, N. Y., market and reshipped from there to other points. During this season 248 permits were issued for 203,685 ears of corn entering Massachusetts, 16 permits for 25,200 ears of corn entering Vermont, and 56 permits for 43,900 ears of corn destined for points in New York outside the area, a total of 320 permits for 272,785 ears of corn.

In the Buffalo, N. Y., market the situation was different, as no green corn grown outside the area was shipped out of that market, and no permits were requested.

In the New England area a large amount of work was required in issuing permits. The destinations and other details of these shipments are given in Tables 9 and 10.

TABLE 9.—*Farm products and cut flowers grown outside of the infested area for which permits were issued for reshipment to points outside of the New England area from June 1 to December 31 in 1924, 1925, and 1926*

Destination	Beans			Beets			Celery			Green corn		
	1924	1925	1926	1924	1925	1926	1924	1925	1926	1924	1925	1926
	Bush.	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*
Connecticut	706	394	719	151	70	184	796	1,478	599	-------	42	23
Delaware	-------	-------	-------	-------	-------	-------	-------	-------	-------	1	-------	-------
Maine	5,888	3,572	5,501	860	849	850	5,537	6,344	7,033	1,267	2,878	1,982
Massachusetts	1,989	1,218	1,576	369	470	297	2,363	5,520	3,637	15	356	84
New Hampshire	1,270	733	891	522	425	363	2,229	3,284	3,290	292	578	873
New York	66	17	107	1	4	9	359	554	496	3	5	70
North Carolina	-------	-------	-------	-------	-------	-------	1	-------	-------	-------	-------	-------
Rhode Island	499	170	383	94	39	296	459	1,259	771	-------	2,823	12
Vermont	1,046	690	969	463	317	647	2,850	3,663	3,851	64	109	54
Canada	648	286	298	91	46	66	734	660	904	-------	4	59
England	-------	-------	-------	-------	-------	-------	4	-------	-------	-------	-------	-------
Ireland	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	[1] 6
Total	12,112	7,080	10,444	2,491	2,220	2,712	15,332	22,762	20,581	1,642	6,795	3,163

[1] Ornamental stalks.

TABLE 9.—*Farm products and cut flowers grown outside of the infested area for which permits were issued for reshipment to points outside of the New England area from June 1 to December 31 in 1924, 1925, and 1926*—Continued

Destination	Pop corn				Broomcorn		Corn shucks, 1925	Rhubarb, 1926	Aster, 1924	Chrysanthemum, 1924	Gladiolus, 1924
	1924	1925	1924	1925	1924	1925					
	Bbls.	*Bbls.*	*Car.*	*Car.*	*Bales*	*Bales*	*Bales*	*Bush.*	*Each*	*Each*	*Each*
Connecticut		10	6	2	17	17	3	5			
Maine	10	15	40	115	46	20	264	1	89		66
Maryland					171						
Massachusetts	70	41	203	247	9	31	199	8	198	12	676
New Hampshire	72	35	72		48	18					
New Jersey									24		
New York			1		277		20				12
Pennsylvania					91						
Rhode Island					50	8	79	3			
Vermont	132	58	42	14							36
Virginia					1						
Canada					117						
Total	284	159	364	378	827	94	565	17	311	12	790

TABLE 10.—*Corn and broomcorn grown outside the quarantined area, for which permits were issued for reshipment to points outside the New England quarantined area, January 1 to December 31, 1926*

Destination	Commercial corn, shelled	Pop corn		Seed corn, shelled	Broomcorn
		Cob	Shelled		
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Bales*
Connecticut		45	12,860		1
Georgia					1
Maine	570,471	13,490	16,520	224	82
Maryland					83
Massachusetts	43,500	3,910	21,500		177
New Hampshire	21,000	600	2,200		
New York			600		615
Ohio					30
Pennsylvania					246
Rhode Island					20
Vermont	3,864	5,300	4,250		2
Canada				375	350
Total	638,835	23,345	57,930	599	1,607

ISSUING PERMITS FOR THE SHIPMENT OF GOODS PACKED IN OAT OR RYE STRAW

In order to facilitate the shipment of goods packed in oat or rye straw, permits are issued to large commercial houses using hay or straw originating outside the infested area, upon satisfactory evidence as to the origin of the material. In the case of individuals or small concerns who make occasional shipments it is necessary for the inspectors to issue permits as required.

The number of shipments of merchandise packed in oat or rye straw that were shipped out of the eastern Massachusetts area under permits during the seasons of 1924 to 1926, inclusive, are shown in Table 11.

TABLE 11.—*Shipments from the infested area of New England packed in oat or rye straw which originated outside the infested area, made under permits, from June 1 to December 31 in 1924, 1925, and 1926*

Destination	Number of shipments			Destination	Number of shipments		
	1924	1925	1926		1924	1925	1926
Alabama	5	207	215	New Mexico	1	14	24
Arizona	2	11	6	New York	1,095	1,250	1,024
Arkansas	8	207	205	North Carolina	91	431	443
California	175	122	203	North Dakota	3	81	37
Colorado	35	4	13	Ohio	200	357	473
Connecticut	1,557	1,267	1,327	Oklahoma	20	122	231
Delaware	10	14	18	Oregon	31	21	18
District of Columbia	40	110	110	Pennsylvania	401	523	791
Florida	252	819	827	Rhode Island	983	1,141	1,219
Georgia	65	449	527	South Carolina	13	466	567
Idaho		8	13	South Dakota	2	171	137
Illinois	235	350	371	Tennessee	21	113	96
Indiana	22	222	371	Texas	56	531	630
Iowa	26	11	56	Utah		2	1
Kansas	11	139	169	Vermont	1,350	1,683	2,613
Kentucky	22	94	75	Virginia	69	200	186
Louisiana	22	177	213	Washington	35	8	13
Maine	4,252	4,044	5,775	West Virginia	19	20	88
Maryland	58	52	124	Wisconsin	64	35	119
Massachusetts	7,063	6,399	5,194	Wyoming	2	1	8
Michigan	150	488	302	Hawaii	11		
Minnesota	113	73	104	Canada	55	69	15
Mississippi	7	201	270	Cuba	1		
Missouri	87	144	199	England	4		
Montana	2	11	24	Mexico			45
Nebraska	10	87	156	Miquelon			12
Nevada	1	2					
New Hampshire	2,948	3,676	4,595	Total	21,880	26,724	30,376
New Jersey	175	97	124				

PREVENTING SHIPMENTS IN VIOLATION OF THE QUARANTINE

A constant watch is maintained at steam and electric railroad and steamship terminals to prevent violations of the quarantine. A similar watch is kept over long-distance autotrucks leaving the wholesale market districts for points outside the quarantined areas. Inspectors also are stationed during the growing season on all highways at State lines within the infested areas for the purpose of stopping and inspecting vehicles to ascertain whether they are carrying products included in quarantine No. 43.

Attempted violations of this law are frequent in the case of automobilists who buy ears of green corn at roadside stands and attempt to carry them across the quarantine lines. In Ohio, on all roads leading from the quarantined area, from July 15 to September 25, 1924, a total of 926,399 automobiles were stopped by the inspectors, and 42,081 ears of corn were seized. In an examination of this corn 504 cobs were found to be infested and to contain a total of 606 borers. Large quantities of corn also were intercepted and taken back within the lines.

Beginning with the season of 1921, two men were stationed at Detroit to cooperate with the customs officials in preventing the entry of products subject to the European-corn-borer foreign quarantine through the ports of Michigan from the Province of Ontario. Table 12 shows the quantity of products denied entry into the United States through Michigan ports during the season of 1924 under the revision of quarantine No. 41 in effect at that time.

TABLE 12.—*Produce and flowers subject to the European corn-borer foreign quarantine denied entry into the United States from Canada at ports in Michigan during the season of 1924* [1]

Pop corn and field corn	Green corn on cob	Beets with tops	Beans in pod	Celery	Spinach	Rhubarb	Bouquets of flowers	Flowers (funeral pieces)	Shipments packed in oat and rye straw
Bushels 2,892	*Bushels* 2,625	*Bushels* 4,260	*Bushels* 1,780	*Bushels* 147	*Bushels* 68	*Bushels* 1,492	2,748	24	10

[1] 16 truck loads of corncobs also were refused entry and 5 freight cars were returned for cleaning

REPRESSIVE MEASURES

THE IMPORTANCE OF CLEAN-UP WORK IN THE PREVENTION OF SPREAD

The writers believe that properly planned clean-up work is very effective in reducing the numerical abundance of the corn borer to such an extent as to prevent important economic damage, and in retarding the spread of the pest. However, a program with extermination as the objective is not considered feasible because it would entail destroying all of the infested material in every field, over very large areas, most of which are only lightly infested, and because of the great probability that sufficiently large numbers of the insect would escape the clean-up to reestablish infestation.

The spread of the corn borer in Ohio, Michigan, Indiana, and Pennsylvania, and the development of a very heavy infestation near the headwaters of the Ohio River, have made possible its dispersion, through floating infested material, to all of the States along the Ohio and the lower Mississippi. The intensification of the infestation along the shores of Lake Erie also has increased the possibility of dispersion by flight of the adults from such areas.

The high infestation in the counties of Elgin, Essex, Kent, and Middlesex in the Province of Ontario, Canada, is very dangerous because of the heavy east-and-west traffic through that district and its proximity to the Corn-Belt States.

The development of a severe infestation near any large middle-western city would render possible the rapid spread of this insect to most of the important corn-growing States.

The presence of the insect in many of the commonly grown vegetables and flowers in the New England area renders the infestation in this section particularly dangerous because of the many possible means of dispersion.

Since the above-mentioned areas contribute materially to the natural dispersion of the corn borer, special efforts have been made to combat the insect in these areas by organized clean-up work.

THE LAKE ERIE REGION

The infested areas in New York, Pennsylvania, Ohio, Indiana, and Michigan differ from the New England area in that weeds, field crops, vegetables, and flowering plants are only rarely infested by the corn borer, at the present time, except when such plants are closely associated with corn in badly infested fields. In many of the townships recently invaded by the borer the infestation is extremely

light. Moreover, in many of the townships involved only a small portion of the cultivated lands are planted to corn, and the early-planted fields usually sustain the greater infestation. In any locality where the general farm practice involves the feeding of cornstalks to livestock as silage or dry fodder or in any other form, the infestation is usually very light, whereas in areas where large quantities of corn residues are allowed to remain from year to year the maximum infestations develop.

Any clean-up work to be undertaken by the Federal and State authorities should be based upon a careful summer survey to determine density of infestation. The method of procedure should consist of the destruction of infested material that is not likely to be utilized or destroyed by the owners, such as stalks or high stubble left standing in fields, unfed corn shocks remaining in the field or barnyard in the late spring, and scattered stalks in the barnyard or in the field after plowing. This work, where carefully done, should reduce existing infestations to such an extent as to prevent important economic damage, retard the dispersion of the insect, and greatly lessen the danger of its being carried to uninfested territory.

CLEAN-UP WORK ADAPTED TO THE LAKE ERIE REGION

It should be remembered that ordinary farm operations, such as feeding the cornstalks either as silage or as dry fodder and plowing under the stalks or stubble, destroy many corn borers. The efficiency of control on the farm by modification of these common practices may be increased by educational work to encourage the use of shredders, the building of silos, cutting the cornstalks low where the farm practice involves this method, carefully turning under corn stalks or stubble, and the burning of unfed corn shocks and scattered cornstalks in the spring before the moths emerge (not later than May 1). The importance of cutting cornstalks low, where the farm practice involves the cutting of corn, is illustrated by Table 13, which gives typical larval populations in stubble in Ohio during the fall of 1924. Attention is also directed to the discussion, later in this bulletin, relating to corn stubble as an important source of reinfestation (p. 83).

TABLE 13.—*Distribution of larvæ of the European corn borer in cornstalks in Ohio during period September 10 to November 3, 1924*

Date of observation (1924)	Total larvæ	Number and percentage of larvæ at or below—															
		3 inches		6 inches		9 inches		12 inches		15 inches		18 inches		21 inches		24 inches		27 inches	
		No.	*P. ct.*	*No.*	*P. ct.*	*No.*	*P. ct.*	*No.*	*P. ct.*	*No.*	*P. ct.*	*No.*	*P. ct.*	*No.*	*P. ct.*	*No.*	*P. ct.*	*No.*	*P. ct.*
Sept. 10 to 16	547	16	2.9	40	7.3	61	11.1	91	16.6	108	19.7	124	22.7	140	25.6	168	30.7	185	33.8
Sept. 17 to 25	226	10	4.4	23	10.2	26	11.5	46	20.4	53	23.5	67	29.6	68	30.1	85	37.6	95	42.0
Oct. 1 to 8	173	7	4.0	15	8.7	25	14.5	41	23.7	46	26.6	61	35.3	67	38.7	78	45.1	95	54.9
Oct. 23	135	7	5.2	23	17.0	36	26.7	52	38.5	67	49.6	81	60.0	85	63.0	92	68.2	----	----
Nov. 3	110	11	10.0	25	22.7	36	32.7	46	41.8	63	57.2	73	66.4	78	70.9	82	74.6	----	----

THE INFESTED AREA OF NEW ENGLAND

The infested area of Massachusetts is here described in some detail in order to show plainly the necessity of adopting direct repressive measures as part of the work of preventing the spread of the

European corn borer, and because conditions similar to those existing around Boston may develop near some other large city if the spread of this insect is not checked. The Boston area includes a densely infested central district having a border of lightly infested territory.

The Lightly Infested Territory

The lightly infested territory includes all of the infested towns in New England that are not listed as belonging to the central district. In general the border territory contains no heavily infested weed areas similar to those around Boston, because the weeds in the open spaces outside the cultivated land consist principally of such perennial species as are seldom attacked by the corn borer.

The area planted to corn is very small, as most of the country is woodland, and the farm land is largely devoted to meadow, only a few acres being arable land. The cornfields are small and scattered, and the cornstalks usually are cut and fed to livestock, so that the conditions in this district are not favorable for the corn borer. The infestation in many towns is light and appears to be maintained by flights of moths from the central district or from the more densely infested towns.

The Central Densely Infested District

The central densely infested district includes the cities of Boston, Cambridge, Somerville, Everett, and Chelsea, and the adjacent market-garden towns, including Watertown, Belmont, Brookline, Arlington, Winchester, Woburn, Stoneham, Melrose, Medford, Malden, Revere, and Winthrop.

These cities and towns contain large vacant lots and dumping grounds within their limits, many of which support growths of weeds, such as cocklebur, smartweed, pigweed, and barnyard grass. Under normal conditions these are seldom cut or burned, so that such places furnish very favorable places for the rapid multiplication of the corn borer unless proper precautions are observed. The infestations in these weedy areas during the period 1919 to 1923 varied from a few thousand to over 1,000,000 individuals to the acre.

There are also many small patches of sweet corn, the stalks of which are often heavily infested and must be destroyed soon enough to prevent the emergence of corn-borer adults.

These vacant lots, dumping grounds, and small gardens, unless they are treated properly, furnish places where the insect may breed through generation after generation and produce millions of moths to infest the cultivated crops near by and aid in the general dispersion of the pest. The Massachusetts clean-up law has operated so effectively that the numerical abundance of the borer and the resultant damage have greatly decreased during the past four seasons, as will be shown in another part of this bulletin. (Annual progress of infestation, p. 133.)

The market gardeners in the Massachusetts area are heavy shippers of vegetables, such as beets, celery, and rhubarb, which are susceptible to infestation in this locality but which have not as yet commonly been found to be infested in other States. These fields of vegetables are cultivated intensively under irrigation, several crops being grown on the same land during a single year. As these crops are grown

rapidly, kept carefully cultivated, and are cleaned up for a new planting soon after harvest, the conditions on many of these farms are not generally favorable for the maintenance of a large population of corn borers. On some of the farms, however, weeds are allowed to grow around the buildings or in such fields as can not be profitably cultivated, and there is little incentive for the farmer to keep these places cleaned up as long as large weed areas remain undisturbed on unused land contiguous to his farm.

The real danger in the New England area, therefore, is the very great number of corn borers, which are difficult to discover and control, concentrated in a large industrial center which furnishes many varied means of spread. The problem of preventing spread from this area by any police system, unaided by direct repressive methods, obviously is difficult, as the insect population is so great and the means of spread are many. Under these conditions it is clear that direct repressive measures must be used to reduce the numbers of this insect to a point where police or regulatory work in prevention of its spread can be reduced to a minimum.

CLEAN-UP WORK ADAPTED TO THE NEW ENGLAND AREA

The writers believe that effective clean-up work in New England should continue to be directed especially to the densely infested central district and that clean-up methods in all districts should be continued as at present. The possibility of keeping this district reasonably free of the European corn borer has been demonstrated by control experiments carried on by the Bureau of Entomology. Except for the first year, these experiments did not cover all of the cities and towns previously mentioned as belonging to the central district, and they have not been continuous year after year. The work, however, undoubtedly has greatly retarded the spread of the corn borer in New England, and many million corn borers were destroyed that otherwise might have been carried to distant points.

The repressive measures used included the burning of infested cornstalks and weeds in the fall and early spring and the destruction of weeds during the summer by mowing and burning or by the application of herbicides. The burning work destroyed from 95 to 99 per cent of the borers present in the fields treated, while the summer mowing and spraying destroyed many larvæ of the first generation and reduced the weed population during subsequent years by changing the weedy areas into grasslands. Since the greater number of the corn borers in Massachusetts were concentrated in the corn patches and weedy fields around Boston, it is apparent that cleaning up these fields each year has been a major factor in preventing the spread of this insect.

In planning the permanent reclamation of suburban infested areas the following measures should be considered:

The irregular surface of dumping grounds should be leveled, and subsequent dumping should be done only at the edge of the fill where leveling may proceed as filling continues. The weeds commonly found growing on dumping grounds may be destroyed by burning, although spraying is preferable, since in many cases the dumps are located in sections where the fire risk is an important consideration. After the dumping grounds are freed from the host plants of the corn borer and are leveled, the cost of maintaining them in that condition

is not excessive and should not exceed $15 per acre each year for mowing or spraying.

Vacant lots are easier to clean up and may be permanently reclaimed in from two to three years. In cleaning up such lots it is best to start by burning the weeds during fall or early spring to destroy the great numbers of corn borers present. This should be followed by summer mowing or spraying to destroy the weeds before they go to seed. As most of these vacant lots have a good stand of quack grass (*Agropyron repens* Beauv.), this soon crowds out the weeds where burning and spraying are continued for two or three seasons; and as this grass is not commonly infested by the corn borer, such fields remain practically free from this insect. The clean-up should include some leveling, and the removal of obstructions, so that the grass may be cut with a mower or scythe. It has been observed that in many instances where a clean growth of grass was obtained it was cut for hay each year, and maintenance cost thus eliminated.

Some suburban fields that include recently abandoned market-garden land covered with a heavy growth of annual weeds may best be handled by plowing the land and sowing it to grass. In cases where a good stand of lawn grass is obtained, fields become permanently reclaimed, as most of them are held for building lots and soon are occupied by residences, the owners of which keep up the lawns.

In the small patches of kitchen garden all cornstalks must be utilized or destroyed. In most cases the owners destroy the stalks voluntarily after they have been shown the necessity for such action.

CLEAN-UP WORK CARRIED ON BY THE BUREAU OF ENTOMOLOGY

Clean-up work for the control of the corn borer has been carried on at various times by the States interested or by the Federal Government, and the impression may have been created that control measures have been carried out very thoroughly on a large scale and yet have failed to prevent the spread of this insect. As a matter of fact, the work which was started in New York and in Massachusetts in 1919 under State appropriations was discontinued for lack of funds the following season. Sufficient funds have never been available for carrying on such work on a large enough scale for several successive years in all of the infested areas, or even throughout a single area. The Bureau of Entomology began such work near Boston and in western New York, but these operations were in the nature of experiments, were not very extensive, and were not carried to completion. Nevertheless, this work demonstrated the possibility of retarding the spread of the insect by proper means where continuously applied.

EARLY EXPERIMENTS

The Massachusetts Area

During the spring of 1919 the work was carried on by the Bureau of Entomology in the infested area around Boston, with a fund of $113,000 furnished by the State of Massachusetts. All of the more densely infested towns were cleaned up by large crews of men who gathered and burned the infested material. Because of insufficient

funds, no similar work covering all of the infested towns was done subsequently.

During the fall of 1919 and spring of 1920 experimental work was done with especially designed burning machines and other apparatus for destroying infested material. The oil-burning machines used were developed to a high degree of efficiency during this season and the seasons that followed. A few of the more heavily infested weed fields in the market-garden towns were burned, but, as previously explained, it was not possible to cover the infested area thoroughly.

During the fall of 1920 and the spring of 1921 about 700 acres of weed areas, cornstalks, and other infested material were burned by use of oil-burning machines in Arlington, Belmont, Medford, Revere, Watertown, and Winchester, six of the principal market-garden towns, and also a small acreage in the cities of Somerville and Cambridge. The work was thorough and complete, so far as it went, but should have included about 300 acres of weeds in the cities of Boston, Cambridge, Somerville, and Everett, which are in the center of the heavily infested district. In order to secure effective repression it should also have included the destruction of standing cornstalks in several market-garden towns adjacent to those where work was done, but funds were not then available for such extensive work.

Experiments in weed spraying in the Boston district were carried on during the summers of 1920 and 1921, but these experiments involved less than 200 acres of weeds, which constituted only about 20 per cent of the acreage that should have been sprayed to effect the control of the first generation in this area. These experiments furnished information as to the value of spraying with herbicides for the eradication of such weed patches as afforded permanent breeding places for the borer and indicate the possibility of destroying the larvae of the first generation.

Since the spring of 1921 no clean-up work at public expense has been undertaken in this region, and during the summer of 1922 the corn borer was exceedingly numerous in the Boston market-garden district and caused much injury to sweet corn and vegetable crops. A very large increase in the infested areas throughout New England was discovered that year by scouting.

The writers believe that this great increase in the density of infestation and the extensive spread which occurred during the season of 1922 in the New England area indicate that the clean-up work carried on from 1919 to 1921 reduced the damage to crops and retarded spread in those years and that such repressive measures are justifiable for the protection of growing crops and for checking the spread of this insect until biological or other satisfactory control is achieved. Such belief is strengthened by the fact that the injury by the corn borer in Massachusetts during 1922 was so great that it resulted in the enactment of the Massachusetts "clean-up law," which required all growers or property owners to clean up or utilize all infested plant residues, thus practically duplicating the clean-up work previously conducted at public expense. The private clean-up work resulting from the enactment of this law has contributed greatly to a progressive decrease in the intensity of corn-borer infestation in New England since 1922, as will be discussed in another section of this bulletin (p. 140).

The New York Areas

During the spring of 1919 a very thorough clean-up campaign was carried on, at a cost of $100,000, by the State department of agriculture in the infested area near Schenectady, in eastern New York. Nearly all of the corn stubble which had not been plowed under on the farms in this area was gathered and burned, and in addition small patches of corn in the suburbs of cities and villages were destroyed. No similar work has been done since by the Bureau of Entomology in that area.

During the fall of 1920 and spring of 1921 clean-up work was undertaken by the Bureau of Entomology near Silver Creek in western New York. This operation included the gathering and destroying of corn stubble and cornstalks on about 700 acres of the more heavily infested farms. These activities ceased in the spring of 1921. The results obtained were negative, as a more severe infestation occurred during the following season. No doubt this was caused by some agency outside of the area cleaned up, presumably by flight from Canada and the Cattaraugus Indian Reservation, where no clean-up work had been done for several years.

SUMMER CLEAN-UP METHODS USED

Summer clean-up work was found especially useful in the two-generation area of New England. In order to effect the control of the corn borer in this area it seems necessary to eradicate, as far as possible, the weeds on waste land around Boston, and this work of eradication should be done in summer before the weeds produce seed. Summer clean-up work is directed at the destruction of the first generation of the corn borer, and where carefully carried out should result in greatly reduced infestation of cultivated plants by the second generation.

The Bureau of Entomology has carried on experiments to discover methods that could be used in summer control work in the Massachusetts area, and the cost and practicability of the work. The methods employed were spraying with herbicides and mowing the weeds, later gathering them into piles and burning them.

Neutral sodium arsenite was used as a herbicide with good success in experimental work in the spraying of weeds during the season of 1923. The approximate cost, including labor and materials, was $11 per acre. A formula for this spray solution is given on page 42.

Mowing and Burning Infested Weeds

Mowing and burning weeds in summer is effective in control work because it results in the destruction of larvæ of the first generation of the corn borer. Where the plants are mowed close to the ground and promptly burned nearly all of the borers are destroyed, but many practical difficulties are encountered in carrying out this work. Much of the land is rough, and it is impracticable to use a horse-drawn mower, so that the work must be done by hand. Such work should be done after the weeds have made a good growth but before they go to seed, and it would be difficult to organize a large enough force of laborers to do the work in this short time, as it is not easy to find men who are able and willing to use a scythe. As it is impossible in

most cases to mow the weeds closer than within 4 inches of the ground, many young seedling plants are uninjured, and some of the larger plants put out sprouts from the stubs, so that new growth springs up rapidly. Although the weeds on these areas could probably be eradicated by such mowing and burning if the work were carried on for several years, the experiments already conducted in the control work show that mowing is less effective than spraying with chemical weed killers.

Spraying Weeds with Herbicides

Spraying weeds with herbicides was found to be of practical value in corn-borer control in two-generation areas where the weeds are heavily infested. Herbicides tend to eradicate the principal host-plant weeds by preventing the production of seeds; the land is then occupied by the fine-stemmed perennial grasses, such as quack grass, which start new growth after the weed tops are killed and smother the new annual plants which start from the seed in the ground. Those herbicides which consist largely of arsenic also destroy many larvæ which die from eating the poisoned foliage, as well as from lack of food, or from mechanical injuries due to the wilting and drying of their host plants.

CHEMICALS USED IN WEED SPRAYING

Many chemicals have been used for weed control, but only a few of these are applicable to large-scale work on land occupied by weeds of several or many species. In spraying to destroy weeds infested with the European corn borer, it is necessary to use a herbicide that will kill the most resistant of the annual weeds, such as smartweed, lamb's-quarters, and wild lettuce. It requires a large quantity of herbicide solution to wet an acre of rank-growing weeds and a correspondingly large quantity of chemical, so that some of the bulky chemicals, like iron sulphate and sodium chloride, are not economical to use because of the expense involved in handling them.

Iron sulphate.—Iron sulphate has been used for killing dandelions in lawns and mustard in grain fields. It could be used in the corn-borer area to spray roadsides and meadows, as it kills ragweed and other annuals. It is not so efficient as sodium arsenite for application to heavy growths of weeds, because it does not kill all species, and such a large quantity is required per acre that the expense of handling it is great.

Sodium chloride.—Common salt is useful as a herbicide under some conditions, but such large quantities per acre are required that the labor of handling it is excessive.

Fuel oil.—Orchard-heating oil and kerosene have been used for killing weeds and are effective for killing some species, such as wild garlic. In the experiments carried on in corn-borer control work, light fuel oil was used and appeared to be as effective as sodium arsenite but was more expensive. Further experiments are necessary to determine its value in this work.

Sodium arsenite.—Sodium arsenite is one of the most effective of the chemical weed killers and is the basis of most of the proprietary herbicides on the market. It kills practically all vegetation if applied in sufficient strength, and only a small quantity is mixed with each

hundred gallons of water, so that little labor is required in mixing. It has the disadvantage of being poisonous to livestock, and of killing the tops of grasses, so that it can not be used in pastures or meadows. In the experiments discussed herein a commercial herbicide containing this chemical was used and proved effective and well adapted to the work.

As the price of the commercial solution appeared to be high as compared with the cost of white arsenic, it seems probable that the work could be done cheaper with a homemade solution of sodium arsenite.

METHOD OF APPLYING HERBICIDES

Any type of sprayer may be used in applying herbicidal solutions. For spraying young weeds on level land a horse-drawn traction sprayer is useful, but the tanks on such sprayers are small and require frequent refilling, which slows up the work where a large quantity of solution is required per acre. Orchard sprayers could be used for spraying headlands and small patches of weeds on the farm, and compressed-air sprayers of about 4-gallon tank capacity for spraying small patches of weeds or scattered weeds on rough land. For large operations on rough land, where a large quantity of solution must be applied, the large power sprayer is most useful.

In the experiments carried on by the Bureau of Entomology in the Boston district a large power sprayer carrying a 400-gallon wooden tank and a triplex pump, mounted on an autotruck, was used. A single line of 1-inch hose was run from each tank and fitted with a solid-stream nozzle carrying a $\frac{3}{16}$-inch or $\frac{1}{8}$-inch tip.

The method of operation was to run out the entire length of hose and, working back toward the pump, spray a strip from 30 to 50 feet wide, and repeat this operation until the entire field was covered. Where the field to be sprayed was near a brook or pond, the pump was set up near the water, and a long line of hose was extended to where the work was being done. With this large spray unit it is practicable to extend about 1,000 feet of 1-inch hose to reach the work and 300 feet of working line beyond that. Where the work was located at a considerable distance from the water supply, or the area to be sprayed was small, the hose was disconnected and the truck sent for water when necessary.

EFFECT OF HERBICIDES ON WEEDS

The sodium-arsenite solutions kill all green vegetation with which they come in contact when they are used in sufficient strength and applied so that the leaves receive a uniform coating. The effect of sodium arsenite is seen about three hours after the application, in the wilting of some of the terminal leaves, and in a few days all of the sprayed leaves turn brown and dry up. The stems of the older plants may remain green for some time, but in from 10 to 15 days the tops of all sprayed plants are dead.

Annuals.—Nearly all annuals are easily killed by herbicides, especially broad-leaved species. In experiments carried on by the bureau near Boston, pigweed, cocklebur, and ragweed were easily killed, while smartweed and lamb's-quarters were killed by the stronger solutions of sodium arsenite. Barnyard grass sprouted again from the roots when young plants were sprayed, and further

experiments are necessary to determine the possibility of killing this grass.

Perennials.—The perennial weeds are difficult to kill with herbicides, as new sprouts spring up from the roots after the tops are killed, but they may be completely destroyed by repeated applications or by a single very strong application. Clumps of tansy and goldenrod were sprayed in June, 1921, at Arlington, Mass., with a solution containing sodium arsenite and the tops were killed. Much of the goldenrod started new growth later, but many plants were dead. Most of the tansy sprouted again from the roots, but clumps that were thoroughly sprayed so that the tops died down to the roots, with no live sprouts showing, did not recover. The stalks in a clump of tansy stand so close together and the foliage is so dense that it requires extra care to apply the solution to all of the foliage.

EFFECT OF HERBICIDES ON SUBSEQUENT PLANTS GROWING IN THE FIELD

Herbicides may be applied at a strength sufficient to kill nearly all species of weeds without injuring the soil sufficiently to prevent the subsequent growth of crops after the land is plowed. Repeated applications of large quantities of sodium chloride or of solutions containing arsenic may be injurious to the soil, but it is not necessary to apply them in large quantities. Fuel oil and kerosene applied in strengths sufficient to kill weeds will not injure the growth of later crops where the land is plowed before planting.

In the Boston market-garden district many vacant lots are covered with a large variety of rank-growing weeds, but it has been found possible to kill such weeds with adequate quantities of the sodium-arsenite solution. Where this was applied in sufficient quantity and strength to kill the most resistant annual weeds, it killed the tops of all plants, including the perennial grasses, such as quack grass. It did not, however, kill the roots of quack grass, which started new growth and soon smothered out the more slowly growing weeds, so that this operation tended to produce a clean growth of grass on the land. On land which had always had a strong stand of grass, one spraying was sufficient to eliminate the weeds, but other fields sometimes required several sprayings extending over two or three seasons. As slender-stemmed grasses are not attacked by the corn borer, the reclaimed fields do not act as breeding places or sources of infestation to adjacent cultivated crops.

EFFECT OF HERBICIDES ON THE CORN-BORER EGGS, LARVÆ, AND PUPÆ

From June 4 to June 17, 1921, many species of weeds bearing corn-borer egg clusters were sprayed with a solution containing sodium arsenite, and some with fuel oil. The sodium-arsenite solution did not kill the eggs, while the fuel oil killed practically all of them. The fuel oil appears to be more effective in this respect than the sodium arsenite, although, when eggs hatch on foliage sprayed with sodium arsenite, many of the young larvæ must die from eating the poisoned foliage or from lack of food.

Cocklebur, ragweed, and smartweed were sprayed early in August, 1920, with a proprietary solution of sodium arsenite. These were mature plants that had flowered and were forming seed, and contained pupae and nearly full grown larvæ of the corn borer. When

these plants were examined about 10 days later it was found that some moths had already emerged from the pupae and that 22 per cent of the pupae and 39 per cent of the larvæ had been killed, presumably by the chemical. It is apparent, therefore, that a portion of the nearly full-grown larvæ may pupate and moths may emerge from the pupae after the plants have been sprayed with these solutions.

Sodium-arsenite solution should be applied at a time when it will destroy the largest possible number of larvæ of the first generation. This period begins at about the time of the maximum hatching of the eggs and extends to the time when the larvæ begin to pupate.

HOW TO MAKE THE STOCK SOLUTION OF SODIUM ARSENITE

The solution was made up according to the following formula, which may be called the California formula:

Neutral sodium arsenite—

Granulated caustic soda (sodium hydroxide) 95 per cent Tech	10 pounds.
Refined white arsenic (arsenic trioxide) 98 per cent Tech	20 pounds.
Water	5 gallons.

The caustic soda was weighed out and placed in 1-gallon oyster cans, which held just 10 pounds when the material was shaken down; it is deliquescent and can not be kept in paper bags.

The white arsenic was weighed out in 20-pound lots in large ⅛-barrel kraft-paper sacks. One bag of arsenic (20 pounds) and one can of caustic soda (10 pounds) were used to each 5 gallons of water to make about 5 gallons of stock solution, which was the dose for each 400-gallon tank of spray solution.

For large quantities the stock solution was made up in a cast-iron kettle holding about 45 gallons. Thirty gallons of water were first placed in the kettle. Six cans of caustic soda were then emptied into the kettle, one can (10 pounds) at a time, as rapidly as possible, but the solution was stirred a little after the emptying of each can. Six cans of white arsenic were then added, one sack (20 pounds) at a time, and the solution was stirred after adding the contents of each sack.

The chemicals should be scattered along the side of the kettle and should not be dumped in one place at once, for this would be likely to cause the solution to boil. (The literature on this subject says the solution should not be permitted to boil.) Some of the white arsenic will float on the surface and it will require considerable stirring to get it all into solution, so it is better to add the next lot before the first is completely dissolved. When all of it has been added, about five minutes' stirring is sufficient to produce a clear solution. The solution should not be allowed to boil throughout, which may occur if the chemicals are added too rapidly to the water, but it is impossible to prevent slight boiling when each lot of arsenic is added.

The solution was stirred with a wooden paddle about 8 feet long, so that it was possible for the operator to stand some distance away from the kettle and avoid danger from splashing. The solution should be stirred from the bottom because much of the arsenic settles there.

No fire or outside heat was required. The dissolution of the caustic soda heated the water, and the chemical action which took place

upon the addition of the white arsenic furnished sufficient heat to produce a clear solution of sodium arsenite without the use of fire.

After the solution cooled it was transferred to a barrel or to 5-gallon oil cans. One 5-gallon can (containing 20 pounds of white arsenic) was sufficient for a 400-gallon tank of diluted solution ready for spraying.

Precautions.—The temperature of the heated solution is higher than that of boiling water, and care should be taken to avoid accidents from splashing or from upsetting the kettle. The kettle with 30 gallons of solution weighs something over 500 pounds, so it should be carefully placed before work is begun. The hot stock solution should be allowed to cool before it is used to make the dilute solution.

CAUTION.—*Under no circumstances should the water be poured over the dry caustic soda, as to do so would be dangerous.*

FALL AND SPRING CLEAN-UP METHODS

The fall and spring clean-up work included the destruction of weeds, cornstalks, and other infested material by various methods, such as burning, boiling, steaming, and crushing, with the object of destroying the larvæ and pupæ of the hibernating generation and thus preventing the emergence and spread of the moths in the spring from the densely infested fields.

BOILING INFESTED MATERIAL

Boiling was resorted to only where the material was so full of moisture as to render burning impracticable. The apparatus used for boiling material was a 1-ton steamer truck, equipped with an oil-fired steam boiler carrying a pressure of 600 pounds. Superheated steam at 800° F. was used to heat water in a 200-gallon U-shaped wooden tank mounted on this truck. This tank was divided into two compartments, each kept about two-thirds full of water.

The material to be treated was gathered in the field and placed in coarse-mesh wire baskets holding 2 bushels, and lowered into the water, the temperature of which was kept at 212° F. About one-half minute was required to treat each basketful. The divided tank permitted the use of two baskets; while one was cooking, the other was being refilled.

This method of treatment is 100 per cent effective, as all borers subjected to it are destroyed. Corn stubble and crop remnants of infested garden plants, such as beets, celery tops, and cornstalks, which, when fed to livestock are only partially eaten and thrown out in waste piles and then are difficult to burn, were treated in this manner. It would probably be the most practicable way to dispose of the waste from corn-canning factories where silos are not available for utilizing this material.

STEAMING INFESTED MATERIAL

Applying live steam to material infested by the corn borer is also a method practiced with success. The apparatus used for this purpose by the bureau consisted of an upright nine-horsepower steam boiler (fig. 15) carrying a pressure of 100 pounds, water being supplied by a steam pump. Fifty feet of 1½-inch steam hose was run from the

boiler to a nozzle (fig. 16) made of 1½-inch iron pipe in the form of a cross 2 feet each way, having small apertures 3 inches apart for the exit of the steam. This was placed on the ground and infested material piled upon it to secure penetration by live steam. The pile was then covered with a heavy canvas, 10 feet square, provided with a small hole near its center to allow the insertion of a thermometer for ascertaining the temperature. Steaming for five minutes at 220° F. was sufficient to kill all insect forms.

In operating by this method it is advisable to have two lines of hose with two nozzles and two pieces of canvas, so that one stack can be prepared while another is steaming. The stacks (fig. 17)

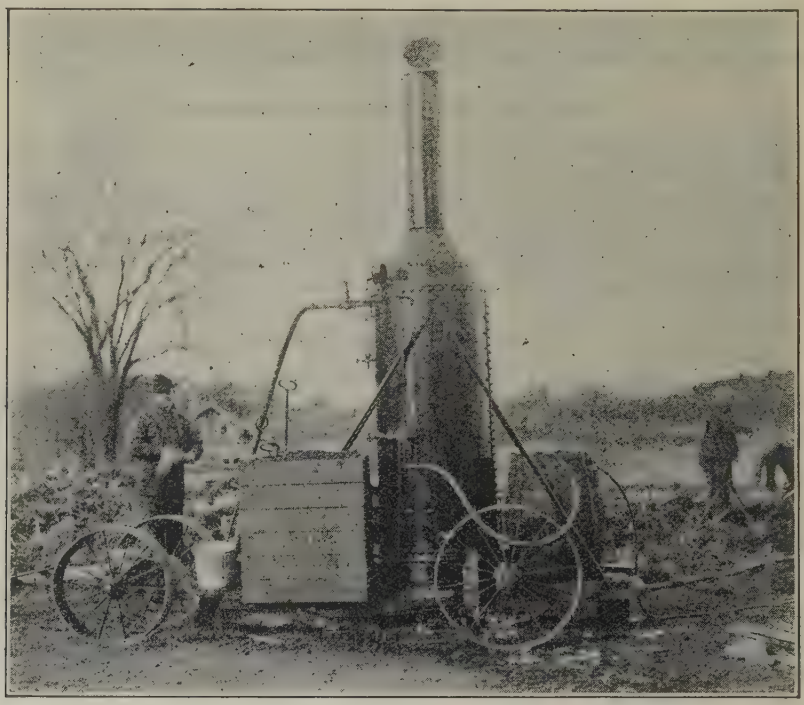

FIG. 15.—Boiler used for supplying steam in steaming infested corn stubble

of infested material should be about as large as an ordinary haycock. Small cloth sacks about three-quarters filled with sand were laid on the edges of the canvas around the pile, to prevent it from rising when steam was applied, and to confine the heat.

CRUSHING INFESTED MATERIAL

Machinery for crushing cornstalks, stubble, and weeds has been used successfully in some phases of the clean-up work.

This was accomplished by means of an especially designed apparatus consisting of two heavy corrugated rollers held together by massive springs, capable of exerting a pressure of many tons on the material passed between the rollers. These were mounted in a heavy steel frame and driven by means of sprocket wheels and a steel roller chain, directly from the main driving shaft of a 3-ton autotruck on which the apparatus was mounted.

The material was fed in on one side (fig. 18, A) of the machine and removed from the other side (fig. 18, B) after being crushed. This was one of the methods resorted to when infested material was in such condition that burning was not practicable. This method would be justifiable only where clean-up operations are to be conducted on a large scale. It is not advisable to attempt crushing operations with a small machine, as the results would be of little value.

Burning Infested Plants With Special Machinery

Burning infested plants while these are standing in the field is an effective method of destroying the European corn borer, since all the

Fig. 16.—The cross-shaped outfit used for steaming piles of corn stubble

larvæ in such plants may thus be destroyed, if the work is done properly. Burning operations, however, should be carried on before the grass starts in the spring, as green grass around the base of the weed stalks prevents the full heat of the flames from reaching the larvæ in the lower parts of the stalks.

The oil-burning outfit (fig. 19, A) used by the bureau consisted of a 600-gallon steel tank and a triplex bronze pump having a bore of 3½ inches and a stroke of 1¾ inches, packed with an oil-resisting packing, and mounted on skids to fit a 3-ton truck. The pump was driven directly from the main driving shaft of the truck by means of a steel roller chain operating on sprocket wheels. The cooling sys-

tem of the engine was connected to a coil in the oil tank, which warmed the oil to some extent, decreasing its specific gravity slightly, which was advantageous. The apparatus was so constructed as to permit operating several lines of ½-inch oil-pressure hose at the same time. These lines of hose, varying in length from 100 to 1,000 feet, were run directly from the machine to the burner.

Two types of portable burners were used. One of these was mounted on a two-wheeled carriage, carrying 13 nozzles, burning over a strip 12 to 15 feet in width. (Fig. 19, B.) This type of burner is adapted mainly for level ground. A hand burner (fig. 20, A)

FIG. 17.—Steaming a pile of corn stubble covered with canvas which is held down by sacks of sand. The thermometer is inserted through a hole in the canvas near the top of the pile

was used wherever burning was required in small areas. This is especially adapted for operation on headlands and banks of ditches. It is constructed of 11 feet of ¼-inch iron pipe, to one end of which is attached a hose connection and ¼-inch globe valve for controlling the oil supply. A ¼-inch cross is mounted on the other end, with a short nipple in the forward opening of the cross, and a ¼-inch by 9-inch nipple in each side opening. Quarter-inch ells fitted with short nipples are attached to the ends of the 9-inch nipples, and spray nozzles are attached to all three short nipples.

The nozzles used are especially constructed to insure that the oil is so finely broken up as to vaporize as soon as the nozzles be-

FIG. 18.—A, Close-up view of the crushing apparatus; B, the crushing apparatus mounted on a motor truck

come heated, so that it is entirely consumed and no residue whatever is left on the ground (fig. 21). Conical strainers are inserted at each end of the hose line, and the nozzles also contain strainers to prevent

FIG. 19.—A, power sprayer built especially for pumping oil to the burners. This sprayer may be rigged with as many as four lines of ½-inch hose and will supply two portable burners, or from four to eight hand burners; B, view of the portable burner working in an infested field

clogging. The oil used may be either kerosene or light fuel oil, not heavier than 0.42 specific gravity.

The oil is forced by the pump through the hose to the burners, where it is lighted at the nozzle for the burning process. In order

to cover the greatest possible space with a minimum quantity of oil, a large number of nozzles were tried, and one was finally obtained that proved satisfactory.

Property owners who wish to practice burning may use any reliable sprayer, either hand or power, provided it is capable of maintaining

FIG. 20.—A, close-up of the flame from the hand burner along a stone wall, B, burning weeds along a stone wall with a hand burner, using a portable sprayer for pumping the oil

100 pounds pressure, and by utilizing a spray rod with a Bordeaux nozzle. Caution should be exercised to have the nozzle opened as little as possible at 100 pounds pressure, so that no oil will be left on the ground unconsumed. It is advisable to procure ½-inch oil hose

if possible, as the ordinary spray hose soon deteriorates when in contact with oil.

Oil burning of weed areas, headlands, and ditches may be done most economically in the spring, when the material to be burned is dry. At that season it is possible to destroy from 95 to 99 per cent of the borers. It is possible to burn weeds when they are green, and even where the weeds are not entirely consumed by the fire the heat generated is so intense that the borers are killed. The cost of burning the weed areas varies from $12 per acre up, depending upon the fuel used and the condition of the weed growth. Clean, light fuel oil of the specific gravity mentioned is the cheapest for large operations. Kerosene is easier to obtain and cleaner to handle. After the hose and sprayer have been used in this work they should be thoroughly washed with soapsuds. Burning over weed areas where the weeds have been mowed is helpful, as many borers are

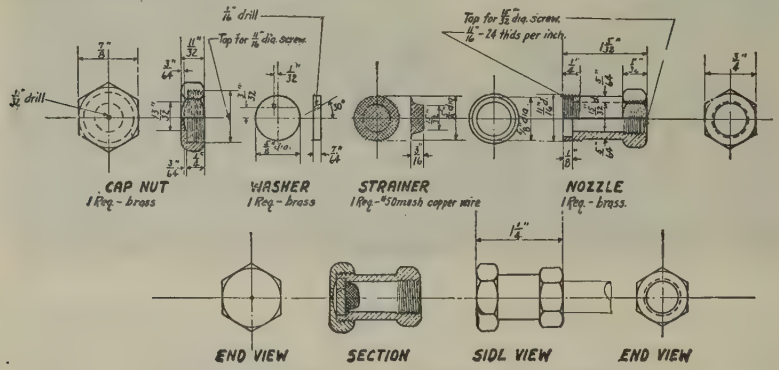

FIG. 21.—Oil-burning nozzle, assembly and details

likely to be left in the stubble. Oil burning is of much assistance in destroying material that has been piled in heaps, or cornstalks that have been raked into windrows.

CONTROL AND RESTRICTIVE METHODS ADAPTED TO GENERAL FARMING

FEEDING INFESTED PLANTS TO LIVESTOCK

The feeding of infested plants to livestock is one of the most effective methods for combating the corn borer, and, in addition, is a most desirable agricultural practice, since the food value of the fodder, except in cases of very severe infestation, is not materially injured by the presence of the insect. Infested plants may be fed as silage, or direct from the field, or in the form of shredded or finely cut fodder. When properly carried out, any one of these methods results in the destruction of a very large proportion of the borers contained in the plants.

Feeding Infested Plants as Silage

In order to obtain best results with the silo, from the standpoint of corn-borer control, the infested plants should be cut as close to the ground and as early in the season as conditions will permit. (See Table 13.) Experiments have demonstrated that any borers which escape the silage cutter are destroyed by conditions existing in the ordinary silo.

Late in the summer of 1920 and again in 1921 experiments were conducted in which badly infested corn plants were run through a silage cutter and placed in a wooden-stave silo. Although the knives of the cutter were set to cut ½-inch sections, it was found that a few living larvæ escaped the knives and were included in the bulk of the silage. Twelve wire-screen cages containing sections of infested cornstalks were buried in the bulk of the silage at depths ranging from 1 to 6 feet from the top. Frequent examinations of the close-meshed wire screen, with which the top of the silo was covered immediately after filling, failed to show any migration out of the silo on the part of the larvæ which had escaped the cutter knives. The contents of the silo were examined late in the winter of each year, and no living larvæ were found either in the bulk of the silage or in the sections of infested stalks inclosed in the wire-screen cages. Examinations of silage in farm silos during the winter and spring failed to reveal any living borers, although it was known that severely infested plants were included in the silage.

Special experiments with silage cutters of various types showed that when infested cornstalks were cut at lengths of three-eighths of an inch, five-eighths of an inch, or three-fourths of an inch practically 100 per cent of the borers in the treated stalks were killed. Some of the borers escaped destruction when the stalks were cut into pieces exceeding three-fourths of an inch in length. The equipment used in these tests was new, and all adjustments were made carefully. To insure complete destruction of borers under average farm conditions and to provide a proper margin of safety, it is recommended that all silage-cutting machines used in corn-borer territory be designed and adjusted for not more than a half-inch cut. This precaution is particularly important in instances where, for any reason, the cut material is not placed directly in the silo or utilized or destroyed by other methods soon after treatment.

Feeding Direct From the Field

Ordinarily, livestock will clean up all corn fodder when it is fed green. However, when infested cornstalks, or similar plants, are fed direct (fig. 22, A) without previous cutting or shredding, the uneaten parts should be collected and destroyed, preferably by burning, unless the uneaten portions are trampled deeply into manure.

It is dangerous to permit large quantities of cornstalks to accumulate in barnyards and feed lots (fig. 22, B), unless trampled deeply into manure. An examination of the cornstalks in barnyards and on the surface of manure piles of five typical farms in Lucas County, Ohio, during the spring of 1926, showed living borers present in such cornstalks at the rate of 51 borers per 1,000 linear feet of stalks. No living borers were found in stalks buried deeply in the manure or in finely cut or shredded corn plants which had been used for feed or bedding.

Feeding Shredded or Finely Cut Cornstalks from Husker-Shredders

Shredding or cutting fodder into short pieces, as ordinarily accomplished by machines known as husker-shredders, renders the fodder more acceptable to livestock and greatly reduces the chance that any larvæ contained therein will survive. The existing types of husking machines, commonly termed "husker-shredders," equipped

FIG. 22.—A, open feed lot, or pasture, strewn with cornstalks infested by the European corn borer; B, typical feed lot containing cornstalks infested by the corn borer

with shredder heads or cutter heads, or combination shredder and cutter heads, kill most of the larvæ in infested cornstalks. The efficiency of the machines is increased where care is taken to apply sufficient pressure on the snapping rolls to produce a slight crushing effect.

In the fall of 1925, a series of six tests to determine the efficiency of husker-shredders as aids in corn-borer control was conducted in northwestern Ohio, in cooperation with L. L. Huber and C. R. Neiswander, of the Ohio Agricultural Experiment Station. All of the machines were in operation on farms at the time of the tests. To obtain accurate information with respect to the percentage of larval kill obtained, each machine was cleaned of all débris and soil before the test. Then 100 infested corn plants, the larval content of which had been computed previously, were run through the machine, and the treated material was caught in a large burlap sack attached securely to the outer end of the first section of the blower pipe. All fragments of loose débris and the loose larvæ which dropped from the machine were caught on a large canvas spread underneath the machine. A small sack caught all loose grain, débris, and dirt delivered through the chute from the grain screen. At the end of the test all accumulated débris, soil, etc., within or upon the machine was again cleaned out and added to the material caught at the blower pipe, on the canvas, and at the loose-grain chute. The entire mass of material, except the husked ears, was then very carefully examined for larvæ or their remains. All larvæ recovered during this examination were retained for further observation and were caged, under favorable conditions, until death or development to the adult stage. This precaution was necessary since previous experiences had shown that some larvæ which appeared to have escaped death died later as a result of minor injuries from the machine. Also certain of the larvæ which were seemingly killed revived later—usually only temporarily, however. The results of the tests are summarized in Table 14.

TABLE 14.—*Test of husking machines to determine percentage of corn borers killed and fatally injured by husker-shredder machine, and total percentage of larvæ passed through machine that failed to survive to adult stage*

Test No.	Date of test (1925)	Description of husker	Larval expectancy per 100 plants [1]	Number of larvæ or larval remains found after test [2]			Total number of larvæ found after test	Percentage of larvæ directly killed and fatally injured by machine	Total percentage of larvæ failing to reach adult stage [3]
				Living	Injured fatally	Killed			
1	Nov. 19	6 rolls, cutter head with 2 divided knives	145	7	6	143	156	95.5	99.4
2	do	do	96	6	0	78	84	92.9	100.0
3	Nov. 26	10 rolls, combination cutter and shredder head with 64 knives	106	2	7	70	79	97.5	100.0
4	Dec. 4	4 rolls, cutter head with 4 knives, running full length of head	77	0	2	41	43	100.0	100.0
5	Dec. 7	8 rolls, cutter head bearing 4 divided knives	171	2	4	148	154	98.7	99.4
6	Dec. 9	10 rolls, shredder head with 2 knives	171	9	13	135	157	94.3	100.0
		Total	766	26	32	615	673		
		Average						96.1	99.7

[1] Number of larvæ in plants computed by dissecting 100 similar plants from the same lot of material.
[2] Larvæ the death of which was attributed to winterkilling and other causes are omitted.
[3] Including larvæ reviving temporarily but not surviving to adult stage and those dying from minor injuries.

From Table 14, it is apparent that 96.1 per cent of the larvæ contained in the infested cornstalks used in these tests were killed or injured fatally by the mechanical process involved. Most of the larvæ classified as "fatally injured" died within a short time after the completion of the test. A few such larvæ lingered until the spring of 1926. Only 2 of the larvæ classified as "living" survived to complete their development and emerge as adults, this indicating a total direct and indirect kill of 99.7 per cent of the larvæ involved in the six tests. These figures exclude, necessarily, such larvæ as were present within the cobs of the ears and were not subject to mechanical injury by the husker. The difference between the total larval expectancy shown in column 4 and the total recovery of larvæ or larval remains shown in column 8 may be attributed principally to the difficulty in recovering fragments of crushed larvæ in the mass of the treated material. In test 4 special precautions were taken to secure a sufficient tension on the snapping rolls to hold the stalks tightly and to produce a slight crushing effect. In all the other tests no special adjustments were made in the machines before use. Undoubtedly a higher percentage of direct kill could have been obtained by observing this same precaution in each of the other tests.

Undoubtedly the majority of the larvæ which survive husking-machine operations perish during the process of storing the cut or shredded material, feeding it to livestock, and using the residue as bedding, ultimately to be trampled into the manure, as results from the general practice. In fact, in two experiments (supplementary to those detailed in Table 14), one in which shredded material was stored in a barn and another in which shredded material was placed in a manure pile and trampled, less than 1 per cent of the borers contained in such material succeeded in completing their development and emerging as adults.

In October, 1926, Philip Luginbill conducted a series of tests with husker-shredders at the Monroe, Mich., corn-borer laboratory, in cooperation with the agricultural engineering department of the Michigan State College. The procedure followed was the same as just described. In this series an average of 98.3 per cent direct larval kill was obtained in the material passing through the machines.

In general the experiments showed that the existing types of huskers equipped with shredder heads, or cutter heads, or combinations thereof, will kill a very high percentage of larvæ contained in infested cornstalks. It seems important to emphasize the necessity of keeping a sufficient tension on the snapping rolls to hold the stalks tightly and to produce a slight crushing effect. The experiments did not reveal any superiority of the typical shredder head over the cutter head or the combination of both.

This method of disposing of fodder is strongly recommended and its use in corn-borer territory should be greatly extended.

Clean Up Refuse Around Machines

In the handling of infested corn, prior to cutting or shredding, and also while it is going through the machine, many borers frequently leave the stalks or drop through the machine and are not included in the finished product. For this reason it is imperative that all refuse accumulating around the machine, or in the field or stack from which the fodder was taken, be cleaned up and utilized or destroyed.

Cutting Box Not Effective

The cutting box as ordinarily used has not proved effective in killing borers contained in cornstalks. If used at all, it should be adjusted so as to cut the stalks in pieces not to exceed one-half inch in length, and all portions not eaten by livestock should be cleaned up and destroyed by burning or otherwise, unless trampled deeply into manure.

At Silver Creek, N. Y., during March and April, 1926, H. N. Bartley conducted a series of tests with hand-operated corncutters. When infested cornstalks were cut into pieces averaging 2 inches in length

FIG. 23.—View of barnyard showing portions of corn-borer-infested cornstalks, partially covered by manure

only 36.3 per cent of the contained borers were killed. When the cuts were reduced to an average of 1 inch in length 60.9 per cent of the borers were killed, and when ¾-inch cuts were made 82 per cent of the borers were killed. A power-operated corncutter in this same series killed 97.4 per cent of the borers contained in infested cornstalks, when adjusted for 1-inch cuts. At Elyria, Ohio, in June, 1925, a special type of power-operated silage cutter, adjusted to cut 1-inch sections, gave a kill of 59.2 per cent of the borers contained in infested cornstalks of the previous year. This test was conducted in cooperation with L. L. Huber and C. R. Neiswander, of the Ohio Agricultural Experiment Station. It should be emphasized that the dry, brittle condition of the cornstalks, when the above tests were conducted, caused many of the cornstalks to split before reaching the knives, thus allowing some of the contained larvæ to drop uninjured through the machine.

Effect of Covering or Trampling Infested Cornstalks or Other Material in Manure

Frequent reference has been made in the preceding discussion to the effectiveness of trampling, or covering deeply, infested cornstalks, or other infested material, in manure. To determine definitely the effect of such treatment upon the borer, various field observations and experiments have been conducted from time to time. The results have shown, in general, that practically all borers perish when the infested material is covered completely to depths ranging from 10 to 12 inches, or when such material is covered completely to lesser depths and trampled by livestock, or otherwise compacted. On the other hand, all the evidence shows that when cornstalks are only partially covered by the manure (fig. 23) or are covered to depths of approximately 3 to 6 inches, many of the contained borers survived by migrating to the portions of the stalks not sufficiently covered by the manure. Horse manure, or manure in a heating condition, has given quicker and more positive results than cow manure, and in detailed experiments 100 per cent larval mortality was secured in cornstalks covered completely by not more than 2 inches of this manure.

Typical results from the burying of infested cornstalk sections in cow manure are detailed in Table 15. These experiments were conducted by L. H. Patch at Sandusky, Ohio, in the spring of 1926. In each experiment 25 cornstalk sections containing a natural infestation estimated at 1 larva each were buried in the manure on April 20. In all the experiments except experiment No. 7, all of the manure was isolated in galvanized-iron tubs, and each tub was surrounded by a recovery trap identical with that described in the section pertaining to plowing experiments (p. 67). Experiment No. 7 was placed in a farm manure pile under natural conditions and surrounded by a recovery trap. The manure was not trampled. All experiments were dug up and examined on June 23, approximately two months after the start of the tests. Check material kept under natural conditions showed an average mortality from all causes of 6.7 per cent.

Table 15.—*Results from the burying of infested cornstalk sections in cow manure*

Experiment No.	Description of experiment	Number of larvæ or pupæ found in stalks or manure		Number of larvæ migrating to trap (all alive)	Number of larvæ missing [1]
		Dead	Alive		
1	Stalks buried 6 inches deep, and water added to level of stalks in cage	27	0	0	0
2	Same as experiment 1, except that stalks were buried from 4 to 5 inches deep in half manure and half mud, which was trampled 10 times during experiment	21	0	0	4
3	Stalks buried 7 inches deep; drainage provided for cage	0	0	20	5
4	Same as experiment 3, except that stalks were buried 3 inches deep	4	0	15	6
5	Same as experiment 3, except that only infested portion of stalks were buried	1	[2] 18	0	6
6	Same as experiment 3, except that stalks were buried 4 inches deep and manure was trampled 10 times during experiment	21	0	2	2
7	Stalks buried 10 inches deep in farm manure pile, under natural conditions	24	0	0	1

[1] Difference between number of larvæ accounted for and estimated number of larvæ in cornstalks when buried.

[2] All except one living and one dead larva were recovered in portions of stalks above level of manure.

It is believed that the greater proportion of the larvæ classified as "missing" in Table 15 died in the manure and disintegrated to such an extent as to be unrecoverable. Nine of the borers listed as dead in experiment 7 were found in the manure near the stalks, and no reason can be assigned for their failure to migrate upward, as indicated in experiment 3, unless the additional 3 inches of manure compacted the pile to an extent sufficient to prevent any migration.

In experiments with horse manure in a heating condition it was found that 100 per cent of the larvæ contained in cornstalks were killed when covered at depths ranging from 2 to 14 inches, without trampling or other compacting. When infested cornstalks were covered to a depth of 14 inches by fresh horse manure, 100 per cent of the larvæ were dead in periods ranging from 48 to 96 hours. The temperature of the manure during these tests ranged from 110 to 140° F.

The fact should be emphasized that in ordinary farm practice the large uneaten parts of corn fodder should be kept out of the manure, unless it is possible to work them deeply into the manure or to subject the manure to trampling by livestock.

Artificial Manure

The use of artificial manure is being given a thorough test to determine its possible value as an aid to corn-borer control under restricted conditions. This process requires that infested cornstalks be collected in a stack. The stack is built up one layer at a time each layer being treated with an alkaline nitrogenous fertilizer and then soaked with water. Judging from effects secured with animal manure, this process should prove fatal to corn-borer larvæ, but definite reports must await the outcome of experiments started at Sandusky, Ohio, in the fall of 1926.

Combined Corn Harvester, Husker, and Silage Cutter in Experimental Stage

Cooperative experiments were started in 1926 by agricultural engineers of the Ohio State University and of several large concerns manufacturing agricultural machinery, leading to the construction of a portable combined corn harvester, husker, and silage cutter. This machine is designed to cut standing corn at the ground level, husk the ears, and cut the stalks into pieces not exceeding one-half inch in length, thus securing practically a 100 per cent kill of the borers contained in the stalks. The husked ears are elevated into a wagon accompanying the machine, and the cut fodder is discharged on the ground or, if desired, it may be elevated into another wagon. Tests of this machine, then in the experimental stage of its development, were made late in the season of 1926. Encouraging results were obtained in these tests, and it is believed that with some improvements in the construction of the machine, it will prove a very important mechanical aid in corn-borer control.

PLOWING UNDER INFESTED PLANTS

In reviewing farm practices applicable to mechanical control of the European corn borer, it is apparent that the effectiveness of plowing under infested cornstalks, corn stubble, other crop remnants, and

weeds must be considered, although under conditions unfavorable to clean plowing this method leaves much to be desired as an ideal control practice. The effectiveness of this measure has been made the subject of considerable investigation in the single-generation area of the Lake Erie region as well as in the two-generation area of New England. While much remains to be learned concerning the detailed reaction of the insect in material plowed under, sufficient information has been assembled to warrant the general statement that clean plowing is the best practical method of control for application to fields containing infested cornstalks, corn stubble, weeds, and similar material, in case it is impracticable to cut or break off the stalks close to the ground level and dispose of them by feeding or burning. Judging from information now at hand, it appears that clean plowing alone is more effective than the present methods of cutting stalks or

FIG. 24.—Larvæ of European corn borer in small pieces of trash on soil surface of plowed field. Arrows indicate position of larvæ

breaking them off at the soil surface, raking them into windrows, and burning them, except where such raking and burning are followed by plowing under the remaining débris.

The point should be emphasized that the effectiveness of plowing, from the standpoint of corn-borer control, depends upon turning under the corn remnants and other plant débris so completely that none of it remains upon the soil surface. It requires also that the material plowed under shall not be dragged to the surface by later cultivation until after the moths have emerged. It is imperative that the average plowing methods, throughout the areas now infested by the corn borer, be improved to meet the requisites of corn-borer control, since the careless methods now in vogue leave many pieces of stalks, stubble, and weeds upon the surface (fig. 24). This débris shelters many larvæ which crawl to the soil surface after being plowed under. Such larvæ bore into, or encase themselves in, the débris, and here many of them complete their development to the adult stage. Where such shelter is lacking, the vast majority of the larvæ reaching the soil surface finally perish, either as a result of exposure to the

weather or as a result of the activities of natural enemies, including birds, various insect predators, and parasites.

With respect to the time of plowing as affecting corn-borer control, the experiments thus far conducted indicate that in the Lake Erie region the time of plowing is not important, within general limits, providing all plant material is covered completely. When the stalks are plowed under, in this area, during the late summer, early fall, or in the spring, the greater proportion of the contained larvæ migrate to the soil surface soon after burial. Where plowed under in the late fall, most of the larvæ remain inactive beneath the soil surface throughout the winter and the majority of them migrate to the surface in the spring. The spring migration occurs usually during April, May, and early June, at which time the rise of air and soil temperature, in the presence of suitable soil moisture, stimulates their activity.

In the two-generation area of New England, however, late fall plowing has given the best results, since in this area the behavior of larvæ plowed under in the late fall is different, in one important respect, from the behavior of larvæ plowed under at the same period in the Lake Erie region. In New England the greater proportion of the larvæ which are plowed under in the late fall (after approximately November 1) remain beneath the soil surface in a living condition, and usually within their burrows in the host material, until the late winter or early spring, at which time a heavy mortality ensues. On the other hand, in this area a large proportion of the larvæ which are plowed under in the summer, early fall, or during the spring, migrate to the soil surface in essentially the same manner described for more western conditions. Therefore, in New England late fall plowing is more effective than plowing at any other period, since it combines the larval mortality below the soil surface with the additional mortality experienced by such survivors as succeed in making their way to the soil surface in the spring.

Concerning the proper depth of plowing for best results, it appears from experiments thus far conducted that the depth is not important providing all plant material is covered completely to such a depth that it will not again be brought to the surface by subsequent cultivation or weathering, during the same season, to act as a shelter for migrating larvæ. Results from hand burying of infested cornstalks, at depths ranging from 4 to 12 inches, were very nearly uniform at each depth, with reference to the migration of larvæ to the soil surface. In order, however, to insure proper coverage of the plowed-under material and to reduce to a minimum the possibility of its being dragged again to the soil surface until after the moths have emerged, it is believed that plowing to a depth of at least 6 inches should be adopted whenever possible.

Studies to determine the possible influence of soil types upon the effectiveness of plowing for corn-borer control indicated that the soil type exerted no important influence upon the ultimate behavior or fate of the buried larvæ, providing its physical condition permitted clean plowing, although the movement of such larvæ upwards was delayed for a longer period of time in the sandy and gravelly loams than in the comparatively moist clay and muck. Types of soils tested in these studies included sandy loam, gravelly loam, shaly loam, clay loam, muck, beach sand, and clay soil containing small proportions of loam, sand, and fine gravel.

Experiments in Ohio

To obtain more detailed information concerning the reaction of corn-borer larvæ when plowed under or hand buried during the spring or fall, under various conditions, a series of experiments were conducted at Oakharbor, Ohio, during the spring of 1925, and at Bono, Ohio, during the fall of 1925 and the spring of 1926. These tests were carried out in cooperation with L. L. Huber and C. R. Neiswander, of the Ohio Agricultural Experiment Station, to whom many thanks are due for the courtesies extended. Doctors Huber and Neiswander initiated these experiments in Ohio during 1924, and the tests detailed herein, conducted at Oakharbor and Bono during 1925 and 1926, were an extension of the 1924 experiments and based principally upon the preliminary results secured by Huber and Neiswander during that year, as well as upon the plowing tests conducted by F. W. Poos and L. H. Patch at the Sandusky, Ohio, corn-borer laboratory of the Bureau of Entomology.

EXPERIMENTS AT OAKHARBOR, OHIO

The main experiment conducted during the spring of 1925 consisted of plowing under, or hand-burying, infested cornstalks in seven series during the period from March 25 to May 19. Each series, as detailed in Table 16, consisted of two lots of infested constalks plowed under cleanly in a space 30 by 30 feet. A special effort was made to keep the soil surface free of trash. The larval content of the stalks in each experiment was estimated by dissecting at least 100 stalks from the same lot of material from which the plowed-under stalks were taken. In one lot of each series a specially devised "recovery trap," described on page 67, was erected adjacent to the last furrow on all four sides. In the other lot of each series the recovery trap was erected at a distance of 10 feet from the plowed area in Series II and V, at a distance of 15 feet from the plowed-under area in Series III and VI, and at a distance of 20 feet from the plowed-under area in Series IV and VII. The space between the recovery trap and the area where the stalks were plowed under was plowed also as a part of the operation of plowing under the stalks. As a check (lot 3) in each series, 100 cornstalk sections, artificially infested with a total of 200 larvæ, were hand-buried to a depth of 6 inches in a space 2 by 2 feet and surrounded by a recovery trap, 40 by 40 inches, of the same type as in the other two lots.

The plowing depth varied from 6 to 8 inches. The soil was a rather heavy clay loam, tile-drained.

In one supplementary series (D) a total of 1,000 larvæ, contained in cornstalk sections and mixed with corn débris, were hand-buried to a depth of 6 inches in a space 6 by 6 feet. The recovery trap was erected at a distance of 25 feet from the outer edge of the space where the larvæ were buried on all four sides. The space between the recovery trap and the buried larvæ also was plowed as a part of the operation in preparing the ground for the experiment. See Table 16 for details.

In another supplementary series (C) a total of 150 cornstalk sections, infested artificially by a total of 300 larvæ, were hand-buried to a depth of 6 inches, in 12 different pits distributed throughout a

plowed area measuring 15 by 15 feet. A recovery trap was erected on the edges of this area.

With few exceptions, when the work was interrupted by stormy weather, the recovery traps were examined every day, including Sundays, and the larvæ found in each trap were removed and recorded.

At the close of the experiments (during the period from May 28 to June 27) all of the cornstalk material was dug up and examined in lot 3 of Series I to VII, inclusive, as well as in lots 1 and 2 of Series D. This included a careful examination of the soil for larvæ and pupæ, or their remains. In each of the remaining lots of Series I to VII a small portion of the stalks was dug up and examined and a square yard of the soil was sifted and carefully examined to a depth of 4 to 6 inches. The stalk sections were not dug up in Series C.

A record of the recoveries and examinations of the experiments is given in Table 16.

TABLE 16.—*Experiments in plowing under and hand burying infested cornstalks at Oakharbor, Ohio, spring of 1925*

(1) Description of experiment	(2) Series	(3) Lot No.	(4) Date experiment started	(5) Estimated number of larvæ in experiment	Recoveries of living larvæ and pupæ						(12) (13) Total recoveries		(14) (15) Total dead larvæ or pupæ		(16) (17) Total larvæ not recovered	
					(6) (7) In recovery traps		(8) (9) On soil surface		(10) (11) Below soil surface							
					Number	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
Plowed in area 30 by 30 feet; recovery trap adjacent	I	1	Mar. 25	500	322	64.4	2	0.4	2	0.4	326	65.2	4	0.8	170	34.0
Hand buried in 40 by 40 inch area; recovery trap adjacent	I	3	...do...	200	148	74.0	4	2.0	4	2.0	156	78.0	2	1.0	42	21.0
Same as Series I, lot 1	II	1	Apr. 6	630	228	36.2	1	0.2	0	0.0	229	36.3	1	0.2	400	63.5
Plowed in area 30 by 30 feet; recovery trap 10 feet distant	II	2	...do...	630	75	11.9	0	0.0	1	0.2	76	12.1	1	0.2	553	87.7
Same as Series I, lot 3	II	3	...do...	200	167	83.5	0	0.0	4	2.0	171	85.5	2	1.0	27	13.5
Same as Series I, lot 1	III	1	Apr. 16	986	247	25.1	0	0.0	2	0.2	249	25.3	2	0.2	735	74.5
Plowed in area, 30 by 30 feet; recovery trap 15 feet distant	III	2	...do...	986	46	4.7	0	0.0	0	0.0	46	4.7	2	0.2	938	95.1
Same as Series I, lot 3	III	3	...do...	200	151	75.5	0	0.0	12	6.0	163	81.5	5	2.5	32	16.0
Same as Series I, lot 1	IV	1	Apr. 27	1,044	245	23.5	1	0.1	0	0.0	246	23.6	1	0.1	797	76.3
Plowed in area, 30 by 30 feet; recovery trap 20 feet distant	IV	2	...do...	1,044	32	3.1	2	0.2	0	0.0	34	3.3	0	0.0	1,010	96.7
Same as Series I, lot 3	IV	3	...do...	200	115	57.5	0	0.0	29	14.5	144	72.0	9	4.5	47	23.5
Same as Series I, lot 1	V	1	May 5	1,275	296	23.2	1	0.1	1	0.1	298	23.4	2	0.2	975	76.4
Same as Series II, lot 2	V	2	...do...	1,275	54	4.2	0	0.0	0	0.0	54	4.2	0	0.0	1,221	95.8
Same as Series I, lot 3	V	3	...do...	200	169	84.5	0	0.0	7	3.5	176	88.0	1	0.5	23	11.5
Same as Series I, lot 1	VI	1	May 12	1,291	343	26.6	1	0.1	6	0.5	350	27.1	1	0.1	940	72.8
Same as Series III, lot 2	VI	2	...do...	1,291	41	3.2	3	0.2	0	0.0	44	3.4	0	0.0	1,247	96.6
Same as Series I, lot 3	VI	3	...do...	200	171	85.5	0	0.0	3	1.5	174	87.0	7	3.5	19	9.5
Same as Series I, lot 1	VII	1	May 19	927	466	50.3	2	0.2	2	0.2	470	50.7	2	0.2	455	49.1
Same as Series IV, lot 2; protected from bird activity	VII	2	...do...	927	86	9.3	8	0.9	2	0.2	96	10.4	2	0.2	829	89.4
Same as Series I, lot 3	VII	3	...do...	200	174	87.0	0	0.0	0	0.0	174	87.0	1	0.5	25	12.5
Same as Series I, lot 1; protected from bird activity	VII	4	...do...	927	607	65.5	6	0.6	1	0.1	614	66.2	1	0.1	312	33.7
Hand-buried in 6 by 6 foot area; recovery trap 25 feet distant	D	1	May 2	1,000	17	1.7	0	0.0	6	0.6	23	2.3	11	1.1	966	96.6
Same as Series I, lot 3	D	2	...do...	200	171	85.5	0	0.0	7	3.5	178	89.0	6	3.0	16	8.0
Hand-buried in 15 by 15 foot area; recovery trap adjacent; 36 feet of corn, 15 feet of weeds on soil	C	1	Apr. 17	300	39	13.0	42	14.0	0	0.0	81	27.0	1	0.3	218	72.7
Same as Series C, lot 1	C	2	Apr. 28	300	72	24.0	8	2.7	0	0.0	80	26.7	7	2.3	213	71.0
Total				16,933	4,482		81		89		4,652		71		12,210	
Average						26.5		0.5		0.5		27.5		0.4		72.1

SUMMARY

40 by 40 inch check cages				1,600	1,266	79.1	4	0.3	66	4.1	1,336	83.5	33	2.1	231	14.4
Recovery trap adjacent				6,653	2,147	32.3	8	0.1	13	0.2	2,168	32.6	13	0.2	4,472	67.2
Recovery trap 10 feet distant				1,905	129	6.7	0	0.0	1	0.1	130	6.8	1	0.1	1,774	93.1
Recovery trap 15 feet distant				2,277	87	3.8	3	0.1	0	0.0	90	3.9	2	0.1	2,185	96.0
Recovery trap 20 feet distant				1,971	118	6.0	10	0.5	2	0.1	130	6.6	2	0.1	1,839	93.3
Recovery trap 25 feet distant				1,000	17	1.7	0	0.0	6	0.6	23	2.3	11	1.1	966	96.6
Recovery trap adjacent trash on soil surface				600	111	18.5	50	8.3	0	0.0	161	26.8	8	1.3	431	71.8

The results of the experiments reported in Table 16 show a pronounced movement of the larvæ to the soil surface, as was indicated in the recoveries of the small check burials (lot 3). The main objective of the experiments, however, was to determine the fate of larvæ which migrated to the surface, the distance of migration on the soil surface, and the proportion of such migrants that would be able to survive and complete their development. In this connection the point should be emphasized that the percentage of larvæ found in the recovery traps does not indicate survival under field conditions, since the protection afforded them by the traps, from weather conditions and some of their natural enemies, would not obtain on the surface of a cleanly plowed field.

Of an estimated total of 16,933 larvæ involved in all the experiments, a total of 4,563 living larvæ (columns 6 and 8), or 27 per cent, was recovered in the traps or found on the soil surface. The larvæ not recovered, consisting of 72.1 per cent of the total, represent the approximate mortality caused directly or indirectly by the plowing and hand burials. Many of the larvæ in this group undoubtedly reached the soil surface and perished as a result of exposure to the weather, or were destroyed by natural enemies. It will be noted that less than 1 per cent mortality is chargeable to larvæ or pupæ found dead under, or on, the soil surface. This figure is perhaps not representative of true conditions because of the extreme difficulty in recovering remains of disintegrated larvæ under, or on, the soil surface of the larger plowings. Winter mortality of the larvæ in cornstalks kept under natural conditions above ground averaged 6.9 per cent. The total mortality from natural causes, including winter mortality, disease, and parasites, can be estimated as not exceeding 10 per cent.

Considering only the tests which simulated field plowing (lot 1 in Series I to VII inclusive, lot 2 in Series II to VI, inclusive, and lot 1 in series D), a total of 12,879 larvæ were plowed under, of which 2,425 or 18.8 per cent were recovered in the traps and on the soil surface. Thus only 18.8 per cent of the larvæ had a chance for survival, under conditions comparable to field plowing, even with the protection afforded by the recovery traps, which in the case of lot 1 in the main series was only a few feet, and for some individuals only a few inches, distant. It seems fair to assume that in the absence of the protection afforded by the recovery trap, considerably less than 18.8 per cent of the larvæ shown above would have survived to complete their development. In series D, which should be noted particularly in this connection, only 17 larvæ out of 1,000, or 1.7 per cent of the whole, were recovered on the surface or in the recovery trap 25 feet distant.

The small percentage of survival in experiments simulating field plowing conditions would indicate that in cleanly plowed fields the migrants would not have much chance for survival, except possibly along the margins of the field where adjacent field borders offer adequate shelter in the form of large weeds and similar plant remnants. Such protection along the margins of severely infested fields of course should be eliminated by burning, or otherwise, as a necessary step in general clean-up operations.

These experiments demonstrated that certain of the larvæ are capable of migrating for appreciable distances on the soil surface. In Series II and V a total of 129 larvæ, or 6.7 per cent of the total larvæ in these lots, migrated a minimum distance of 10 feet in order

to reach the trap. In series III and VI a total of 87 larvæ, or 3.8 per cent, migrated at least 15 feet. In Series IV and VII a total of 118 larvæ, or 6 per cent, migrated at least 20 feet. In series D 17 larvæ, or 1.7 per cent of the larvæ involved, migrated at least 25 feet. (See summary of Table 16.)

Judging from direct observation, and from the examination of the stomach contents of several robins taken in, or in the vicinity of the experimental plots, it is apparent that many of the migrant larvæ were captured by robins. The activities of other species of birds undoubtedly had a part in destroying many of the larvæ that came to the soil surface in the experiments, but no direct evidence of bird activity was obtained, except in the case of robins. Lot 4 of Series VII was protected from birds (fig. 25, A) by a covering of poultry-wire screen (1 mesh to the inch) and lot 1 of the same series served as a check. In the former 65.5 per cent of the larvæ plowed under were recovered in the trap, while in the check 50.3 per cent were recovered. This difference in percentage of recovery was chargeable, apparently, to bird activity. In this connection it should be stated that it was necessary to station a man beside lot 4 for about three days after plowing, until the covering of wire screen was erected, in order to keep the robins away. Incidentally this guard also kept the robins away from the check (lot 1) which was located in an adjoining plot of ground. Ths same conclusion relating to the status of birds was noted in Series VII, lot 2, which was protected from birds by a wire-screen covering. Here 9.3 per cent of the larvæ in the experiment were recovered in the traps, while in the corresponding experiment (Series IV, lot 2) only 3.1 per cent were recovered. These two experiments were started 22 days apart; consequently the results are not exactly comparable. The presence of trees and buildings near the site of the experiment probably created more favorable conditions for birds than would exist under more open field conditions.

In certain of the experiments, notably in Series VII, ants were seen carrying away dead larvæ. Whether ants were the primary cause of the death of the larvæ could not be ascertained.

An examination of the composite graph (fig. 26) reveals the fact that in the series of experiments detailed in Table 16 a distinct relationship existed between the movement of the plowed-under or buried larvæ to the surface and the conditions of air temperature, soil temperature, and soil moisture.

Periods of high soil and air temperatures were reflected very quickly by increased movement of the larvæ to the traps, while a quick drop in temperature, as on April 20, April 28 to 29, and May 5 to 6 was followed by a corresponding decrease in recoveries. This effect was not so evident of course after approximately May 25, when most of the living larvæ had migrated to the surface or had become inactive prior to pupation. Similar effects accompanied the light rains during the course of the experiments, the rains being followed very closely by increased recoveries. During April and May the precipitation in the Oakharbor area was below normal, and it seems probable that the absence of normal soil moisture exerted an important influence in limiting the percentage of migrant larvæ which came to the soil surface. A total of 2.10 inches of rainfall was recorded at Oakharbor during April and May. The normal rainfall for the period in this

section is 5.55 inches, according to the records of the United States Weather Bureau Station at Toledo, Ohio, approximately 25 miles west of Oakharbor. Thus only one-third of the average precipitation occurred in this region during April and May of 1925. In

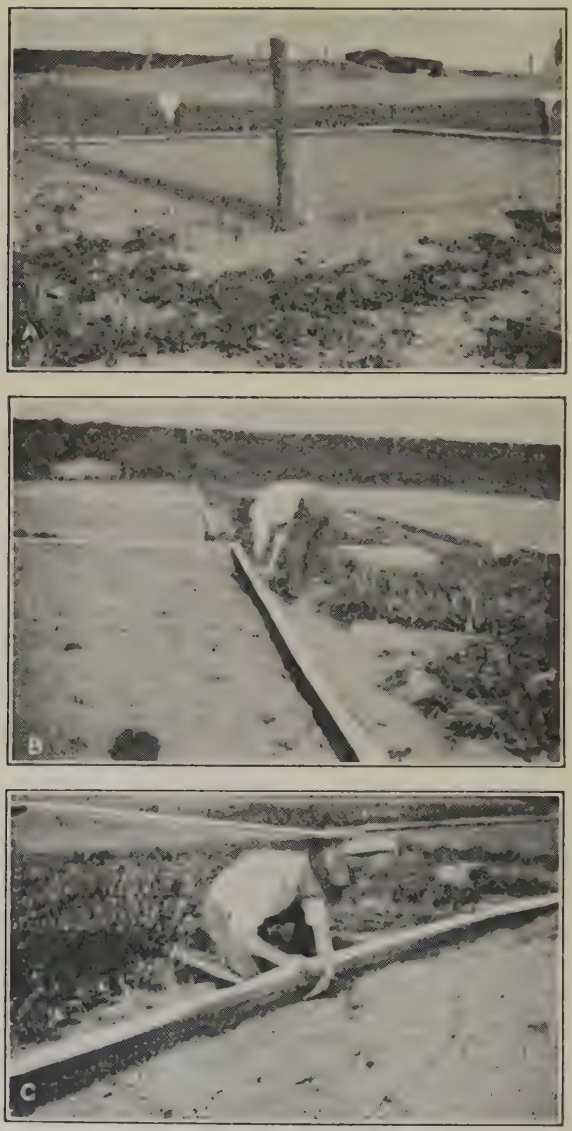

FIG. 25.—A, plowing experiment, inclosed with poultry-wire screen, to test status of birds as aids in corn-borer control; B, type of recovery trap employed in plowing experiments; C, examination of recovery trap to determine presence of larvæ in plowing experiments

Figure 26 the data pertaining to "larval recoveries in traps" are based upon the total number of larvæ found in the traps on each date as compared with the total number of larvæ in the experiment on that date. Recoveries totaling less than 0.1 per cent on any one day are

recorded as 0.1 per cent. Records of soil temperature at a depth of 6 inches, air temperature, and precipitation were taken from instruments of the Ohio Agricultural Experiment Station at Oakharbor, located near the site of the experiments.

No important relationship was noted between the larval recoveries at the four principal points of the compass, as applied to the four sides of the traps. For all the larger experiments, upon which records of this point were made, 2,491 larvæ were recovered. Of this number 30.5 per cent were recovered on the north side of the traps, 21.5 per cent on the south, 22.9 per cent on the east, and 25.1 per cent on the west.

In order to determine whether an important percentage of the larvæ which migrated to the soil surface in these experiments might

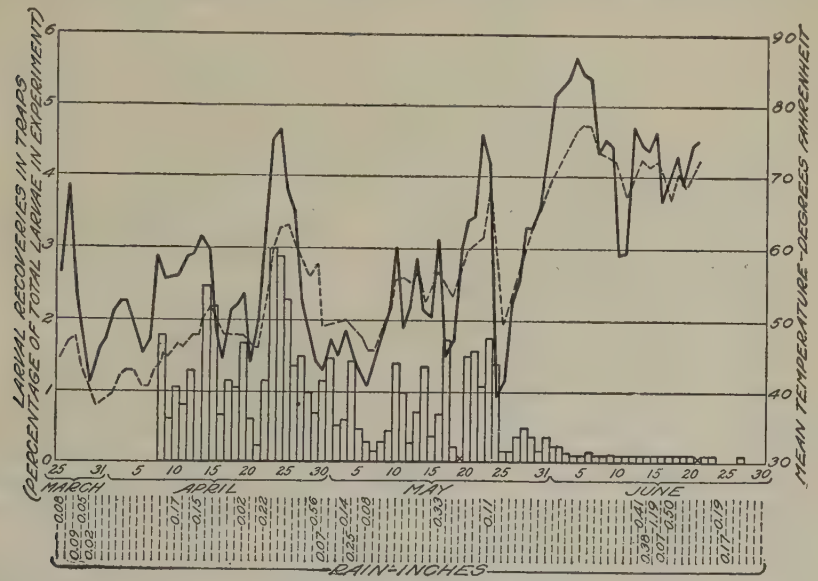

FIG. 26.—Recovery of corn-borer larvæ in traps from spring-plowing and hand-burial experiments at Oakharbor, Ohio, spring of 1925, compared with meterological conditions. Air temperature shown by solid line. Soil temperature (at depth of 6 inches) shown by broken line. Rainfall in inches. Recovery of less than 0.1 per cent shown as 0.1 per cent. X, traps not examined

have escaped from the traps a special test was made of a model trap. Results from this test cage demonstrated that very few if any larvæ could escape from the traps when the traps were kept in good condition. Moreover, a search of miscellaneous trash lying on the soil immediately outside the traps in the main experiment failed to disclose any larvæ.

Description of trap used in experiments.—The recovery trap (fig. 25, B) used in the preceding experiments was constructed as follows: Yellow pine boards 10 inches wide and seven-eighths of an inch thick were set on edge into the soil to a depth of from 3 to 4 inches. All knot holes, checks, etc., were covered with wire screen (20 meshes to an inch). Then a split plastering lath was attached 2 inches below the top of the boards with 1-inch wire brads, and set far enough away from the board to admit a strip of double-corrugated straw-board, 1 inch in width with the corrugations running vertical. The cardboard rested upon the wire brads and could be removed at will for

examination. A 4-inch strip of oilcloth was then attached horizontally to the top of the boards, with the smooth side of the oilcloth downward and overhanging the inside of the trap. The oilcloth was held in place by quarter laths, which were nailed to the top of the boards with ⅞-inch wire brads. The oilcloth strip was held in place horizontally or at a slight downward angle by short lengths of piano wire fastened across the board. One length of the piano wire was held in position on top of the oilcloth and below the quarter lath, while the other length was placed below the oilcloth and held in position by attachment to the board composing the walls of the trap, with short staples. The ends of the piano wire were bent into loops and fastened to prevent the oilcloth strips from flapping and tearing in the wind. The ends of the strips of oilcloth were sewed with fine stitches at the corners of the trap to prevent larvæ escaping at this critical point. Also when a single oilcloth strip was not long enough to extend the length of one side of the trap, the junctions were sewed with fine stitches. The abutting ends of boards and all corners were covered, on the inside of the trap, with strips of wire screen (20 meshes to the inch). All corners were nailed tightly.

By pulling back the top length of piano wire and bending back the oilcloth strip, it was possible to examine the corrugated cardboard strips in place, or remove them for examination if necessary (fig. 25, C). The cells or spaces in the corrugated board proved an ideal shelter for migrating larvæ.

EXPERIMENTS AT BONO, OHIO

The importance of clean plowing was strikingly shown by experiments at Bono, Ohio, during the fall of 1925 and extending to the spring of 1926. These tests were an extension of the series at Oakharbor in the spring of 1925. They were conducted in cooperation with L. L. Huber and C. R. Neiswander, of the Ohio Agricultural Experiment Station, using essentially the same methods of procedure as those in the previous series.

Infested cornstalks were plowed under at intervals from September 25 to December 11, 1925, and inclosed by "recovery traps." The stalks were plowed under cleanly in an area 10 by 10 feet and the recovery traps were erected at varying distances from this area, as detailed in Table 25. To compare the results of average plowing with clean plowing, approximately 11 linear feet of corn débris (stalks, husks, leaves) per 100 square feet of soil surface were placed upon the surface in certain of the experiments as soon as the plowing was completed. A unit of 11 linear feet was selected for this purpose, since field studies in the spring of 1925 had shown the presence of approximately this quantity of corn débris per hundred square feet on the surface of the fields studied. The soil surface of duplicate experiments was kept free of débris to represent clean plowing and to serve as a comparison with the lots representing average plowing. The plowing depth ranged from 7 to 8 inches. The soil was a heavy black clay.

Each series included a small hand-burial with artifically infested cornstalk sections (lot 1), as described for the spring series, to serve as a check.

Except when the work was interrupted by stormy weather or periods of low temperature, the recovery traps were examined on each day of the period represented in Figure 27. On days when examinations of the traps in the small check experiments failed to

disclose any larvæ, the traps of the larger experiments were not examined. All larvæ found in the traps were removed and recorded at the time of examination.

At the close of the experiments (during the period May 17 to June 17) all of the cornstalk material used in the experiments was

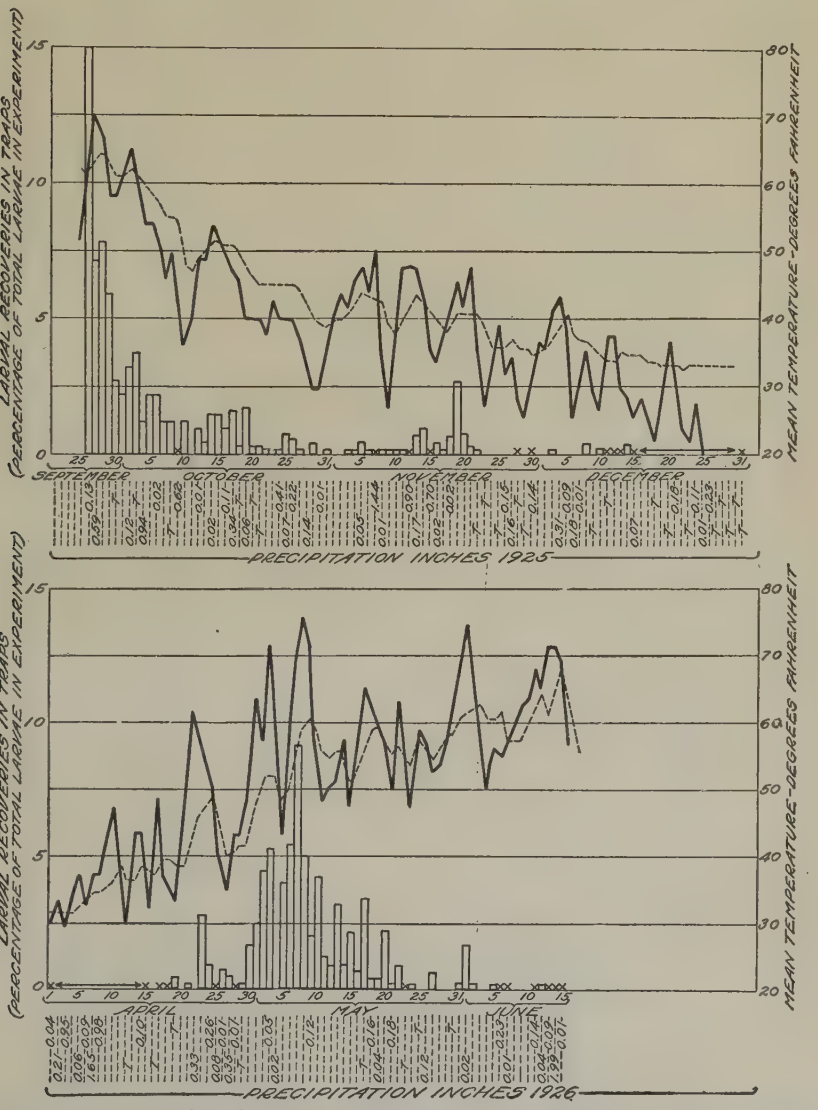

FIG. 27.—Recovery of corn-borer larvæ in traps from fall-plowing and hand-burial experiments at Bono, Ohio, fall of 1925 and spring of 1926, compared with meteorological conditions. Air temperature shown by solid line. Soil temperature (at depth of 6 inches) shown by broken line. Rainfall in inches. Recovery of less than 0.25 per cent shown as 0.25 per cent. X, traps not examined

dug up and examined. The soil in the immediate vicinity of the cornstalks was also examined carefully for larvæ and pupæ, or their remains.

A record of the recoveries and examinations of the experiments is reported in Table 17.

TABLE 17.—*Experimental tests of plowing under and hand-burying infested cornstalks at Bono, Ohio, fall of 1925*

(1)	(2)	(3)	(4)	(5)	Recoveries of living larvæ and pupæ						(12)	(13)	(14)	(15)	(16)	(17)
Description of experiment	Series	Lot No.	Date experiment started	Estimated larvæ in experiment	(6)	(7)	(8)	(9)	(10)	(11)	Total recoveries		Total dead larvæ or pupæ		Total larvæ not recovered	
					In recovery traps		On soil surface		Below soil surface							
					Number	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
Hand-buried in 40 by 40 inch area; recovery trap adjacent	I	1	Sept. 25	100	75	75.0	0	0.0	0	0.0	75	75.0	4	4.0	21	21.0
Plowed-in area 10 by 10 feet; 11 feet of débris on surface; recovery trap adjacent	I	2	---do----	441	226	51.2	9	2.0	2	.5	237	53.7	7	1.6	197	44.7
Plowed-in area 10 by 10 feet; recovery trap 12½ feet distant; 120 feet of débris on surface	I	3	---do----	567	66	11.6	121	21.3	1	.2	188	33.2	12	2.1	367	64.7
Plowed-in area 10 by 10 feet; recovery trap 25 feet distant; 240 feet of débris on surface	I	4	---do----	567	41	7.2	139	24.5	0	.0	180	31.7	7	1.2	380	67.1
Hand-buried in 40 by 40 inch area; recovery trap adjacent.	II	1	Oct. 15	100	30	30.0	0	.0	0	.0	30	30.0	22	22.0	48	48.0
Plowed-in 10 by 10 foot area; recovery trap adjacent; 11 feet of débris on surface.	II	2	---do----	531	292	55.0	21	4.0	6	1.1	319	60.1	26	4.9	186	35.0
Plowed-in 10 by 10 foot area; recovery trap 11½ feet distant; no débris on surface.	II	3	---do----	531	165	31.1	0	.0	3	.6	168	31.7	5	.9	358	67.4
Same as lot 3, except 120 linear feet of débris on surface.	II	4	---do----	531	56	10.5	44	8.3	1	.2	101	19.0	6	1.1	424	79.9
Hand-buried in 40 by 40 inch area; recovery trap adjacent.	III	1	Nov. 3	100	14	14.0	0	.0	1	1.0	15	15.0	48	48.0	37	37.0
Same as Series II, lot 2	III	2	---do----	486	235	48.4	32	6.6	0	.0	267	54.9	5	1.0	214	44.1
Same as Series II, lot 3	III	3	---do----	486	113	23.3	7	1.4	6	1.2	126	25.9	4	.8	356	73.3
Plowed-in area 10 by 10 feet; recovery trap 28 feet distant; 480 feet of débris on surface.	III	4	---do----	486	14	2.9	96	19.8	2	.4	112	23.1	10	2.0	364	74.9
Same as lot 3 of this series, except 120 feet of débris on surface.	III	5	---do----	486	60	12.3	44	9.1	0	.0	104	21.4	5	1.0	377	77.6
Hand-buried in 40 by 40 inch area; recovery trap adjacent.	IV	1	Nov. 21	100	13	13.0	0	.0	0	.0	13	13.0	43	43.0	44	44.0
Same as Series II, lot 2	IV	2	---do----	504	207	41.	20	3.9	2	.4	229	45.4	22	4.4	253	50.2
Same as Series II, lot 3	IV	3	---do----	504	139	27.6	18	3.6	3	.6	160	31.7	16	3.2	328	65.1
Same as lot 3 of this series, except 120 feet of débris on surface.	IV	4	---do----	504	50	9.9	57	11.3	1	.2	108	21.4	14	2.8	382	75.8
Hand-buried in 40 by 40 inch area; recovery trap adjacent.	V	1	Dec. 11	100	25	25.0	0	.0	0	.0	25	25.0	24	24.0	51	51.0
Same as Series II, lot 2	V	2	---do----	356	344	96.6	43	12.1	0	.0	[1] 387	[1] 108.7	4	1.1	0	.0
Same as Series II, lot 3; recovery trap erected in April, 1926	V	3	---do----	356	148	41.6	10	2.8	2	.6	160	44.9	3	.8	193	54.3
Same as lot 3 of this series, except 120 feet of débris on surface.	V	4	---do----	541	88	16.3	87	16.1	0	.0	175	32.4	10	1.8	356	65.8
Total				8,377	2,401		748		30		3,179		297		[2] 4,936	
Average						28.7		8.9		.4		37.9		3.5		[2] 58.9

40 by 40 inch check cages	------	------	------	500	157	31.4	0	.0	1	.2	158	31.6	141	28.2	201	40.2
Recovery trap adjacent; débris on surface	------	------	------	2,318	1,304	56.3	125	5.4	10	.4	1,439	62.1	64	2.7	850	36.6
Recovery trap 11½ feet distant; no débris	------	------	------	1,877	565	30.1	35	1.8	14	.7	614	32.7	28	1.5	1,235	65.8
Recovery trap 11½ to 12½ feet distant; débris on surface.	------	------	------	2,629	320	12.2	353	13.4	3	.1	676	25.7	47	1.8	1,906	72.5
Recovery trap 25 to 28 feet distant; débris on surface.	------	------	------	1,053	55	5.2	235	22.3	2	.2	292	27.7	17	1.6	744	70.7

[1] Excess of larvæ recovered in this experiment is probably due to error in estimating larval expectancy in material plowed under.
[2] Totals and averages do not balance owing to excess of larvæ in series V, lot 2.

An examination of Table 17 shows that 8,377 larvæ were plowed under or buried. Of this number 37.6 per cent were recovered in the traps and on the soil surface (columns 7 and 9). If the number of larvæ recovered in the traps (28.7 per cent) is omitted, it will be noted that only 8.9 per cent (column 9) were recovered in a manner to indicate their survival under field conditions. A total of 3.5 per cent of the larvæ in the experiment were found dead, principally in the stalks dug from bene th the surface. A total of 30 larvæ, representing 0.4 per cent of the total in the experiment, were found alive in the soil or in the cornstalks below the surface. The remaining larvæ in the experiment, constituting 58.9 per cent of the whole number, are classed as "missing." Since two carefully conducted tests of the traps (discussed in detail later) proved the effectiveness of the traps in preventing the escape of migrating larvæ, it appears safe to assume that the "missing" 58.9 per cent (column 17) perished after reaching the soil surface as a result of exposure to the weather, plus the activities of natural enemies, or that they died in the soil and were for the most part unrecoverable in the mass of soil and decaying cornstalks examined at the close of the experiment.

In connection with the possible death of the plowed-under or buried larvæ in the buried stalks, or in the soil, it is interesting to note that of the 500 larvæ included in the five check cages, a total of 141 larvæ, or 28.2 per cent of the whole number, were found dead in their burrows or in the soil near by. (See summary of Table 17.) In the larger experiments (lots 2 to 5) the greater distribution and the quantity of material to be examined for fragments of dead larvæ prevented a sufficiently detailed examination of the exhumed stalks, and of the soil surrounding them, to determine the presence of disintegrated larval remains.

Special attention is directed to the fact that the recording of larvæ as "recovered in the traps" (28.7 per cent of the total in the series) does not signify the survival of such larvæ under field conditions. The records from these traps indicate only the proportion of larvæ which migrated to the soil surface and reached the traps. These traps serve as an effective shelter for the larvæ and a protection from some of their natural enemies and adverse weather conditions, a condition which would not exist on the surface of a cleanly plowed field.

Referring to important points brought out in the summary of Table 17, attention is directed to the results shown in lot 3 of Series II to V, inclusive (column 9), wherein special efforts were made to plow under the stalks cleanly and the soil surface was kept free of débris. In this group only 1.8 per cent of the borers involved in the three lots succeeded in establishing themselves in such small pieces of trash as remained on the soil under circumstances indicating their survival under field conditions. The conditions in this group were designed to simulate clean plowing, and the recovery trap was 11½ feet distant from the plowed area. In comparison, note the duplicate experiments where débris was placed on the soil surface after completion of plowing. In this group (comprising lot 3 of Series I, lot 4 of Series II, IV, and V, and lot 5 of Series III) a total of 13.4 per cent (column 9) of the larvæ established themselves in the trash on the soil surface under circumstances indicating their survival under field conditions.

In two of the experiments where the recovery trap was erected 25 feet distant (lot 4, Series I) and 28 feet distant (lot 4, Series III),

respectively, from the area where the infested cornstalks were plowed under, a total of 235 larvæ, 22.3 per cent of the whole number involved, found adequate shelter in the débris placed on the soil surface. An additional 5.2 per cent succeeded in migrating a minimum distance of 25 or 28 feet, as shown by the recoveries in the traps. This circumstance, of course, leads to the conclusion that large weeds and similar plant remnants along the margins of severely infested fields should be eliminated by burning, or otherwise, as a necessary step in general clean-up operations.

Winter mortality of the larvæ in cornstalks above ground averaged 6.7 per cent in this section. The total mortality from winter killing, disease, and parasites did not exceed 10 per cent. The beneficial activities of birds in destroying the migrant larvæ, as described for the spring series of 1925 at Oakharbor, was not observed during the fall of 1925 or the spring of 1926 at Bono.

The graph (fig. 27) representing the experiments detailed in Table 17 reveals essentially the same relationship between the upward movement of the larvæ to the surface and conditions of air temperature, soil temperature, and soil moisture, as has been discussed in the study of the spring series (fig. 26). When the mean soil temperature, at a depth of 6 inches, dropped below approximately 50° F., in mid-October, the movement of the larvæ upwards decreased very materially and practically ceased when the soil temperature went below 40° F. Upward migration of the larvæ was resumed the following April when the soil temperature reached a mean of approximately 40° F., and became more pronounced when the 50° level was reached. This effect of course was not operative after approximately May 20, when most of the living larvæ had migrated to the surface or had become inactive prior to pupation. The records of soil temperatures, at a depth of 6 inches, were taken from a soil thermograph located at the site of the experiments at Bono, Ohio. The air temperature and precipitation data are from the United States Weather Bureau station records at Toledo, Ohio (14 miles distant). According to the Toledo records, the precipitation during the period from September 1 to December 31, 1925, was 4.78 inches above normal, while the mean air temperature was below normal for each month except September. During April, 1926, the precipitation was 2.84 inches above normal, and May showed a deficiency of 2.57 inches. The mean air temperature during April was 5.4 degrees below normal, while normal temperatures prevailed during May. The excess of normal precipitation in the fall of 1925 and in April, 1926, together with the subnormal temperatures prevailing during October, November, and the following April, may have affected the seasonal activity of the larvæ, but an accurate evaluation of such influences must await the results of further investigation.

Experiments at Silver Creek, N. Y.

Some of the experiments described at Bono, Ohio, were duplicated at Silver Creek, N. Y., in the fall of 1925 and the spring of 1926, the same equipment and methods being used. The final results secured were essentially the same as those reported for Bono, although the percentage of borers migrating to the soil surface in the fall at Silver Creek was lower than were those recorded at Bono from

plowings made on about the same date. The soil was of a light clay type with a small quantity of fine gravel.

Tests of trap used in experiments.—As an additional test of the effectiveness of the trap used in the main series of experiments during the spring and fall of 1925, a 40 by 40 inch trap of this type was prepared on October 21, 1925, and set in position in the soil. This trap was then inclosed by a secondary trap, constructed in the same manner as the first, and placed 1 foot distant from the inner trap, on all four sides. As an additional precaution, the outer face of the outside trap was equipped with corrugated strawboard strips. A total of 500 living larvæ were then buried in the soil to a depth of 8 inches, inside the inner trap. Two hundred of these larvæ were introduced artificially in 100 cornstalk sections, while the remaining 300 larvæ were distributed "free" among the sections. This triple trap was examined daily, and such larvæ as were present in the trap were removed in the routine examination of the traps of the main series. This experiment was in operation until May 11, 1926, and during this period 189 larvæ were recovered in the inner trap, while no larvæ were recovered in the secondary trap or in the outer trap. On November 11, 1925, a similar triple trap was constructed, differing from the first in that the inner trap was 5 by 5 feet in size and the secondary trap 6 by 6 feet. A total of 515 cornstalk sections, containing an estimated number of 500 larvæ (natural infestation), were buried to a depth of 7 inches inside the inner trap. This trap was in operation until May 24, 1926, and during this period 207 larvæ were recovered in the inner trap, no larvæ were recovered in the secondary trap, and a single larva was recovered in the outer trap. This one larva may have originated from sources outside the trap. A review of these two tests of the trap will show that out of a total of 1,000 larvæ involved, 396 larvæ were recovered in the inner trap, none were recovered in the secondary trap, and a single questionable specimen was recovered in the outer trap. The effectiveness of this type of trap for the purpose stated when properly maintained and frequently examined seems obvious.

FENCE-ROW EXPERIMENTS

To determine the status of a typical fence row, or field border, as a shelter for migrating larvæ, a series of tests was conducted as a part of the plowing experiments just detailed. In one test at Oakharbor, Ohio, during the spring of 1925, 1,000 larvæ were buried by hand to a depth of 6 inches in a trench dug adjacent to a fence row containing large weeds, grass sod, and old leaves. This trench, together with 10 linear feet of the fence row, was inclosed by a 10 by 15 foot recovery trap. Daily examinations were made of the recovery trap, and all larvæ found therein were removed and recorded. Birds were observed capturing some of the migrant larvæ. At the close of the experiment on June 17 a total of 12.4 per cent of the number of larvæ in the experiment had been recovered in the trap, and an examination of the weeds and old leaves revealed the presence of 27 living larvæ and 10 living pupæ, which constituted 3.7 per cent of the entire number of individuals in the experiment.

In another similar test with 1,000 larvæ, and protected from birds by poultry-wire netting, at least 17.9 per cent of the individuals involved in the experiment had succeeded in establishing themselves in the weeds and old leaves, at the time of the examina-

tion on June 10 and 12, in one-half of the area included in the experiment, which was examined. This number included 165 living larvæ and 14 living pupæ. Several wire-screen cages were erected over the weeds and sod in the other half of the area, to determine adult emergence. Under date of July 23, C. R. Neiswander sent a tabulation showing the adult recoveries in these cages. This tabulation showed that 71 adults (32 males and 39 females) were recovered during the period from June 22 to July 10. The total indicated recovery from the fence row in this experiment represented 25 per cent of the individuals involved. An examination of the débris in the cages revealed 52 empty pupal cases in curled leaves, 6 empty pupal cases in weed stems, and 10 empty pupal cases on the soil surface.

In order to test the protection afforded by a fence row under more nearly typical conditions than the foregoing, a recovery trap 16 feet long by 4 feet wide was erected in a typical field border at Bono, Ohio, on October 22, 1925. This field border contained a heavy

FIG. 23.—Corn refuse and large weeds along margin of cornfield. Such refuse and weeds provide shelter for the corn borer and should be destroyed

growth of timothy sod, with grass about 6 inches high, and a few standing weed stems and dead leaves. Larvæ were placed in the center of the fence row from day to day; the number of larvæ employed on any one day was designed to correspond with the number of larvæ found in the recovery trap of one of the test cages on that day, thus indicating the degree of larval migration from day to day. The recovery trap was examined as a part of the routine in examining the main series. All larvæ found therein were returned to the center of the fence row. The experiment was continued until June 21, 1926, and to that date a total of 189 larvæ had been placed in the fence row. An examination of the sod, weeds, and leaves in the fence row on the above date revealed a total of 20 living larvæ and pupæ, representing 10.6 per cent of the individuals placed in the fence row.

These fence-row experiments demonstrate the desirability of burning or otherwise destroying all weed growths and similar plant remnants (fig. 28) along the margins of severely infested fields which may provide shelter for migrating larvæ.

Field Observation in the Lake Erie Region

Recent field observations in the Lake Erie region have demonstrated the value of plowing under constalks and stubble as a means of corn-borer control, although in most of the fields included in this study no special effort was made by the operators to plow under cleanly. Results from the examination of 20 typical fields in Michigan, Ohio, and western New York, which were plowed during the fall of 1925 or the spring of 1926, are shown in Table 18. The figures from each field were based upon a careful examination of all plant débris upon the soil surface of 5 square rods of the field, 1 square rod in the center of the field, and 1 square rod in the center of each quarter of the field. From the average number of living larvæ per square rod the population per acre was computed and compared with the original larval population per acre shown by field examinations in the summer or fall of 1925.

Table 18.—*Percentages of larval survival and mortality in fields where cornstalks or stubble were plowed under*

Kind of field	Field No.	Date examined (1926)	Average number of borers, per square rod, in débris	Estimated average number of borers, per acre, in débris	Estimated average number of borers, per acre, before treatment	Percentage of larval survival	Percentage of larvæ killed by treatment [1]
Stubble, plowed in spring	1	May 13	0.2	32	648	4.9	95.1
Do	2	May 17	2.2	352	2,470	14.3	85.7
Stalks, plowed in fall	3	do	4.2	672	8,570	7.8	92.2
Stubble, plowed in spring	4	do	1.4	224	2,770	8.1	91.9
Stalks, plowed in fall	5	May 18	3.8	608	3,148	19.3	80.7
Stubble, plowed in spring	6	do	1.2	192	1,815	10.6	89.4
Stalks, plowed in fall	7	do	1.8	288	6,600	4.4	95.6
Stubble, plowed in spring	8	May 22	5.0	800	1,728	46.3	53.7
Stalks, plowed in spring	9	do	7.8	1,248	7,298	17.1	82.9
Do	10	do	1.2	192	1,333	14.1	85.6
Stubble, plowed in spring	11	May 24	1.6	256	1,333	19.2	80.8
Do	12	May 26	2.6	416	4,727	8.8	91.2
Stalks, plowed in fall	13	May 28	.4	64	10,668	.6	99.4
Stubble, plowed in fall	14	do	5.2	832	31,161	2.7	97.3
Stalks, plowed in spring	15	May 13 to June 4.	[2] 6.0	960	1,130	84.9	15.1
Stubble, plowed in spring	16	June 4	[2] 7.0	1,120	11,520	9.7	90.3
Stubble, plowed in fall	17	June 18	[2] 3.4	544	20,928	2.6	97.4
Stalks, plowed in fall	18	do	[2] 3.4	544	13,606	4.0	96.0
Stubble, plowed in fall	19	June 22	[2] 2.2	352	13,643	2.6	97.4
Stalks, plowed in fall	20	June 24	[2] 1.6	256	6,169	4.2	95.8
Total				9,952	151,265		
Average			3.11	497.6	7,563.2	6.58	93.42

[1] A small percentage of larval reduction, not exceeding 10 per cent, may be attributed to winter mortality, parasites, and disease.
[2] Pupæ or pupal cases, counted as larvæ.

In the 20 fields reported upon in Table 18 a kill of 93.42 per cent was indicated by the samples examined. No explanation can be offered at this time to account for the comparatively high degree of larval survival in fields Nos. 8 and 15, since the quantity of trash on the soil surface, and other cultural conditions, were not appreciably different from those of other fields where a much lower percentage of larval survival was recorded. Successive débris examinations were made at intervals in six of the fields from May 21 to July 6 to determine comparative borer populations in the surface

débris at different periods. The results were so variable, with respect to comparison of borer populations on different dates, that no definite conclusions could be drawn. In certain of the fields the average number of borers per square rod was greater in the middle of May than during late June or early July, whereas in other fields the reverse was true. Some variation of the borer population may be expected from time to time, since in plowed fields certain of the borers are migrating to the soil surface and entering the trash while others are being eliminated by exposure to the weather or by their natural enemies.

A comparison of plowing results with the data secured from fields where poling, raking, and burning was followed by disking small grains (Table 21) indicates that plowing as a single operation to dispose of cornstalks or stubble is more effective than poling, raking, or burning alone. It should be emphasized, however, that under prevailing conditions the results from poling, raking, and burning standing cornstalks, followed by plowing under the remaining débris, have been more effective than those from plowing under entire cornstalks without previous burning. (Table 22.) A comparison of results from different methods of treating infested cornstalk or stubble fields appears in Table 19.

TABLE 19.—*Comparative results from different methods of treating infested cornstalk or stubble fields*

Treatment of fields	Number of fields examined (1926)	Average number of borers per square rod in débris	Estimated average number of borers per acre in débris	Estimated percentage of larvæ killed by treatment [1]
Disked (Table 21)	7	6.97	1,115.2	12.4
Poled, raked, and burned (Table 23)	11	5.45	872.0	58.3
Stalks or stubble plowed under (Table 18)	20	3.11	497.6	93.4
Poled, raked, burned, and plowed (Table 24)	5	.20	32.0	98.7

[1] Natural mortality from winterkilling, parasites, and disease, not exceeding 10 per cent, on an average, is included.

AVERAGE PLOWING METHODS MUST BE IMPROVED

It is believed that the average plowing methods now in vogue, as applied to standing cornstalks or high stubble, can be greatly improved from the viewpoint of corn-borer control. The new and especially designed 16-inch and 18-inch bottom plows recently placed on the market are well adapted for clean plowing. (Fig. 29, A.) Experiments conducted with one of the new 18-inch bottom plows at Sandusky, Ohio, in the fall of 1926 and again in the spring of 1927, demonstrated that, with the aid of a rolling colter and a jointer, standing cornstalks and all trash could be covered completely, without previous treatment. The use of a chain or a wire proved of great help in securing complete coverage. A special attachment of three No. 9 wires, attached as illustrated in Figure 29, B, gave best results under varied conditions of plowing. With this arrangement a complete coverage of standing cornstalks, originally about 10 feet in height, was secured at Defiance, Ohio. In this instance the depth of plowing varied from 5½ to 6 inches, in a heavy clay soil. Agricultural

engineers state that a 14-inch bottom plow, equipped with accessory attachments to aid in covering the stalks, will give satisfactory service if properly adjusted; and furthermore that the skill of the

FIG. 29.—A, standing cornstalks, infested by the corn borer, plowed under cleanly with a wide-bottom plow. Clean plowing of this type covers all plant material with soil and thus eliminates the natural shelter of corn-borer larvæ which may migrate to the soil surface subsequent to plowing. B, method of attaching wires to aid in covering cornstalks and trash infested by the corn borer

operator is as important, within reasonable limits, as the size or the type of plow used. The following is quoted from Parks, Silver, and Park (*5, p. 2, 3*):

The size and type of plow bottom and how the plow is adjusted and equipped is of greater importance than whether the plow is of the walking or wheel type. As a rule the general purpose bottoms bury crop refuse deeper and more completely than the stubble bottoms; obviously, the mild sod types and the extreme general purpose types may handle the stubble better than the typical general purpose bottom. The wider bottoms will probably be found most effective, with the 16-inch bottoms preferable, the 14-inch of second choice and the 12-inch of last consideration.

Effort should be made (a) to maintain an even depth of plowing; (b) to keep a plow cutting its normal width; (c) to use a properly set rolling coulter in conjunction with the jointer; (d) to use special covering devices if necessary; and (e) to use every precaution in the setting of the plow to yield maximum results.

Inasmuch as few walking plows are equipped with rolling coulter and as the average plowman will not do as good work with the walking plow as with the rider, walking plows may not receive first recommendation. There is no objection to the properly adjusted walking plow, providing it is handled by a good operator; is equipped with rolling coulter and jointer; and carries a beam wheel in case of varying soil conditions. If the walking plow is used, one trouble in particular must be avoided, namely, the tendency of the plow to take too much land. This trouble forces the operator to "wing up" the plow, then the furrow slice is not handled properly, and the stubble and trash is pitched higher. In attempting to remedy this difficulty attention should be given to the horizontal hitch adjustment and to the amount of wing bearing. A wheeled plow which is run "winged up" will also fail to handle trash well; hence, keep the plow level.

The set of the rolling coulter and jointer is very important. For standard stubble conditions the position of the coulter on the beam should be approximately over the point of the share when the share is new; should cut one-half to two-thirds the depth of the furrow and be set to cut five-eighths inch to the land. In hard ground, setting the coulter back on the beam of the plow may help. In deep plowing the coulter may have to be raised to give bearing clearance and to prevent dragging of trash. When the trash is dry, good results can be obtained by setting the coulter high and forward. In heavy, wet trash better results are sometimes obtained by moving the coulter close to the shin of the plow so that the coulter blade and shin have a shearing action between them to produce a forced cut as the trash is carried down. On the wider bottoms the combination rolling coulter and jointer will probably be found most effective.

The use of special covering devices may help in getting the stubble under. A covering wire is often used. This is a piece of No. 9 wire about 6 feet long with one end fastened to the yoke of the coulter and the free end allowed to drag under the newly turned furrow slice. In this position the wire is stretched tight under the surface of the slice after the latter is turned. The old method of using a drag chain with the walking plow may be found advantageous. One end of the chain is fastened to the furrow horse's clevis; the other is attached to the plow beam above the bottom and the chain is slacked enough to allow it to drag on the furrow slice as the slice is turned. This helps to fold under the trash.

BORERS SHELTERED IN SMALL PIECES OF TRASH ON SOIL SURFACE

In certain of the fields, where determinations were made of the larval population in the surface débris, a special record was kept of the number of borers found sheltered in small pieces of corn-leaf blades, corn husks, small pieces of weeds, and similar trash which could not be gathered with the type of rake ordinarily used on the farm for such purpose. The number of borers found in these small pieces of trash is compared with the total number of borers found in all the trash on the same areas, in Table 20. The total linear feet of cornstalks in such areas are also recorded.

TABLE 20.—*Percentage of borers found in small pieces of trash in cleaned-off cornfields*

Treatment of field	Field No.	Date examined (1926)	Length of cornstalks per 5 square rods	Borers in all trash per 5 square rods	Borers in small pieces of trash per 5 square rods	Borers in small pieces of trash compared with total number
			Lin. feet	*Number*	*Number*	*Per cent*
Poled, raked, burned	1	May 17	452.5	34	8	23.5
Plowed	2	May 18	112.0	19	6	31.6
Poled, raked, burned	3	do	358.0	39	13	33.3
Disked—stubble	4	May 19	310.5	45	5	11.1
Do	5	May 20	725.0	59	2	3.4
Poled, raked, burned	6	do	474.5	31	3	9.7
Do	7	May 21	763.0	34	2	5.9
Disked—stubble	8	do	411.5	70	6	8.6
Plowed	9	May 22	50.5	25	4	16.0
Do	10	do	224.0	39	8	20.5
Do	11	do	269.8	6	1	16.6
Poled, raked, burned	12	May 24	441.5	19	3	15.8
Plowed	13	do	115.5	8	2	25.0
Poled, raked, burned	14	May 25	374.0	9	0	.0
Disked—stubble	15	do	283.0	18	1	5.5
Plowed	16	May 26	135.0	13	3	23.1
Poled, raked, burned, and plowed	17	do	31.5	0	0	.0
Total			5,531.8	468	67	
Average (per 5 square rods)			325.4	27.53	3.94	14.3

In the 17 fields recorded in Table 20 an average of 14.3 per cent of the total number of borers in the surface débris was sheltered in small pieces of trash, according to conditions found in the samples examined. It is obvious that any method of cleaning up infested cornfields must be designed to eliminate these small pieces of trash.

FIG. 30.—Larva of European corn borer in small fragment of cornstalk on surface of cornfield that had been poled, raked, burned, and disked. Arrow indicates position of the larva

(Fig. 30.) An analysis of results from the different cultural methods represented in the above records shows that in the disked fields 7.3 per cent of the borers were found in the small trash; in the poled, raked, and burned fields 17.5 per cent; in the plowed fields 21.8 per cent; and in the one field which was poled, raked, burned, and then plowed there were no borers found. Incidentally there were on

an average 432.5 linear feet of cornstalks per 5 square rods in the disked fields; 477.3 feet of cornstalks on the same unit of area in the poled, raked, and burned fields; 151.1 linear feet in the plowed fields; and 31.5 linear feet in the poled, raked, burned, and plowed field.

DISKING CORNFIELDS AN INEFFECTIVE CONTROL PRACTICE

Field observations in infested cornfields of the Lake Erie region have demonstrated that disking cornstalks or high stubble, in preparation for the seeding of small grain, is a very ineffective practice from the standpoint of corn-borer control. (Fig. 31.) This practice not only allows a very high percentage of larval survival, but the shade furnished by the growing grain appears to afford an important

FIG. 31.—A, living corn-borer larvæ near base of corn stubble in disked field. Stubble sectioned to show larvæ within. Position of larvæ indicated by arrows

measure of protection to the borers contained in the trash on the surface from the desiccating effects of the sun and wind during periods of high temperature in the spring.

In connection with field observations [3] to determine the survival of larvæ in plant débris on the soil surface at Bono, Ohio, during the spring of 1925, it was noted that during the times of high temperature and drought prevailing thoughout the period from May 31 to June 6, a high mortality developed among the larvæ which had established themselves, prior to pupation, in the débris on fields planted to corn and sugar beets. Under these circumstances little or no shade was afforded to the débris. Readings with a thermometer at Oakharbor on June 4, in the center of the pith of a cornstalk lying on the ground, showed a temperature of 105° F. at 10 a. m., while a similar reading made at the same time between the leaf sheath and the stalk registered 108°. For cornstalks lying on the ground

[3] Conducted in cooperation with L. L. Huber and C. R. Neiswander of the Ohio Agricultural Experiment Station.

at noon on June 5, a temperature of 110° on the outside of the leaf sheath was recorded, and between the leaf sheath and the stalk 120°. The maximum air temperatures, approximately 3 feet above the ground level, at Oakharbor during this period (May 31 to June 6) ranged from 91° to 100°, and the daily mean temperatures ranged from 74.7° to 87°, as shown by thermographic readings. The daily mean soil temperatures, at a depth of 6 inches, showed a range of

FIG. 32.—Field of high corn stubble disked to oats without previous treatment. Under conditions of corn-borer infestation this practice must be discontinued

from 67.2° to 76.3°, as recorded by a soil thermograph, with maximum readings ranging from 72.5° to 83°.

Table 21 shows data relative to borer survival in typical cornfields of Ohio and Michigan when high stubble was disked (fig. 32), during the spring of 1926. The method of examination in these fields was the same as previously detailed.

TABLE 21.—*Larval survival and mortality in fields of high corn stubble disked to small grain, without previous treatment*

Field No.	Date examined (1926)	Borers per square rod in débris	Estimated borers per acre in débris	Estimated borers per acre before treatment	Larval survival	Larvæ killed by treatment[1]
		Number	*Number*	*Number*	*Per cent*	*Per cent*
1	May 19	9.0	1,440	1,718	83.8	16.2
2	May 20	4.2	672	695	96.7	3.2
3	do	11.8	1,888	1,915	98.6	1.4
4	May 21	3.8	608	665	91.4	8.6
5	do	14.0	2,240	2,346	95.5	4.5
6	May 25	3.6	576	1,165	49.4	50.6
7	May 28	2.4	384	405	94.8	5.2
Total			7,808	8,909		
Average		6.97	1,115.4	1,272.7	87.6	12.4

[1] A small percentage of larval mortality, not exceeding 10 per cent, may be attributed to winter mortality, parasites, predators, and disease.

In the seven fields reported upon in Table 21, a kill of only 12.4 per cent by the operation of disking is indicated in the samples examined. A portion of this mortality may be chargeable to winter mortality, parasites, predators, and disease. It seems apparent that, regardless of any other necessary change in farm practice, the disking for small grain on infested cornlands must be discontinued if the corn borer is to be held in check and widespread commercial loss prevented. Where unavoidable, this practice should be limited to fields in which the operations of cutting or breaking off the stalks at the ground level and completely disposing of them, together with all trash, by burning or otherwise, have been carefully conducted.

CORN STUBBLE AN IMPORTANT SOURCE OF REINFESTATION

In a previous publication (*4, p. 95–97*) the authors have shown the importance of the borers left in the stubble as a source of rein-

FIG. 33.—Typical field of high corn stubble. This practice of leaving high stubble must be discontinued in areas infested by the corn borer, unless such stubble is eliminated subsequently by clean plowing or by other methods

festation, and the desirability of cutting corn low and as early in the season as possible. While a certain amount of variation has been evident from year to year, in general, the proportion of the total borer population which remained in stubble of a given height, up to and including 18 inches from the ground, where cornstalks were cut during early November, was from two to three times greater than in stubble of the same height where cornstalks were cut during early September. The proportion of the larval population left in the stubble also varied according to the height of the stubble. Thus from cornstalks cut during the middle of September, 7.3 per cent of the total number of borers in the stalks remained in 6-inch stubble, 16.6 per cent in 12-inch stubble, 19.7 in 15-inch stubble, 22.7 per cent in 18-inch stubble, and 30.7 per cent in 24-inch stubble.

With the purpose of obtaining additional information respecting the status of stubble as a source of reinfestation, a series of 29 fields of corn stubble (fig. 33) was examined in the Bono district of northwestern Ohio, during the fall of 1925. All fields were of the dent-corn type, grown for grain. In the examinations of each field a

total of 500 stubble were dissected, comprising 100 stubble in the approximate center of the field and 100 stubble in the approximate center of each quarter of the field. The first stubble of each unit was taken at random, and from this point 100 consecutive stubble were examined in the row. To determine the larval population in the stubble, the number of larvæ in each infested stubble was recorded. To obtain weighted averages in fields of varying size, the total number of stubble in each field was estimated carefully by counting the number of rows in each field and then counting the number of stubble in a row. The averages were then computed from the estimated total number of stubble in fields under consideration, the estimated total number of infested stubble in such fields, and the estimated total number of larvæ contained in the infested stubble.

A summary of the results secured in the above 29 fields appears in Table 22.

TABLE 22.—*Stubble infestation in cornfields of the Bono, Ohio, district during the fall of 1925*

Field No.	Date examined (1925)	Area of field	Stubble infested	Average larvæ per infested stubble	Average larvæ per 100 stubble [1]	Average height of stubble	Method of cutting
		Acres	*Per cent*	*Number*	*Number*	*Inches*	
1	Nov. 17	10.0	8.2	1.2	9.8	16	Hand cut.
2	do	4.5	1.6	1.0	1.6	9	Do.
3	do	4.0	1.6	1.0	1.6	16	Do.
4	do	7.0	6.0	1.0	6.0	12	Do.
5	Nov. 18	7.5	3.0	1.0	3.0	12	Do.
6	do	2.0	.8	1.0	.8	18	Do.
7	do	5.0	7.2	1.2	8.6	18	Do.
8	do	10.0	16.0	1.1	17.6	14	Machine cut.
9	do	1.5	3.8	1.0	3.8	14	Hand cut.
10	Nov. 19	10.0	19.8	1.2	23.8	14	Do.
11	Nov. 23	6.5	14.4	1.3	18.7	18	Do.
12	do	6.0	15.0	1.1	16.5	16	Do.
13	Nov. 24	6.0	12.8	1.1	14.1	16	Do.
14	do	6.0	8.6	1.0	8.6	12	Do.
15	do	10.0	2.0	1.0	2.0	8	Machine cut.
16	do	9.0	2.4	1.0	2.4	8	Do.
17	do	1.5	1.2	1.0	1.2	21	Hand cut.
18	Nov. 25	9.0	19.6	1.1	21.6	12	Machine cut.
19	Dec. 4	9.5	11.6	1.0	11.6	12	Do.
20	Nov. 30	9.0	.2	1.0	.2	8	Do.
21	do	4.0	.6	1.0	.6	8	Do.
22	do	3.5	.4	1.0	.4	8	Do.
23	do	2.0	4.8	1.0	4.8	16	Hand cut.
24	Dec. 1	4.0	.4	1.0	.4	11	Do.
25	do	3.5	.4	1.0	.4	11	Do.
26	Dec. 2	10.0	.4	1.0	.4	10	Machine cut.
27	Dec. 3	3.0	1.4	1.0	1.4	10	Do.
28	do	7.0	3.8	1.0	3.8	15	Hand cut.
29	Dec. 4	6.0	3.0	1.0	3.0	10	Do.
Total		177.0					
Average [2]			7.38	1.1	8.2	13	

[1] Includes noninfested as well as infested stubble.

[2] Total estimated stubble 1,746,977
Total estimated infested stubble 128,996
Total estimated larvæ in stubble 143,839
Estimated number of larvæ per acre 812.7

Even in fields of comparatively slight infestation an alarming number of borers are left in the stubble and a decided improvement must be made in present practices of leaving high stubble unless such stubble is eliminated by clean plowing or other methods.

An examination of 43 corn-stubble fields, totaling 338 acres in the Bono-Reno section of northwestern Ohio, by L. H. Patch and assist-

ants, during the late fall of 1926, showed that an average of 8.91 per cent of such stubble was infested by the corn borer at the rate of 9.83 borers to each 100 stubble in the field, based upon an average of the samples examined. In the fields representing maximum infestation there were 29.6, 25.4, and 25.2 per cent, respectively, of the stubble infested. Averages were computed from noninfested as well as infested stubble. The above figures show an increase of 21 per cent in the number of borers remaining in the stubble as compared with the number found in a similar examination in the same general section, although not in the same fields in every instance, during the late fall of 1925. In the 43 fields the corn stubble ranged from 4.5 to 15.9 inches in height, with an average of 9.29 inches. This is a reduction of about 4 inches as compared with the average height of stubble in the fields examined in 1925. Ten of the fields were machine cut, four were cut partly by machine and partly by hand, and 29 were cut by hand. Five hundred stubble were dissected in each field, and from these examinations it was estimated that about 319,388 borers, or an average of 944 borers per acre, were present in the stubble of the fields examined.

A similar examination of 27 corn-stubble fields, totaling 155 acres, in the Sandusky, Ohio, district during the late fall of 1926, showed that an average of 7.32 per cent of the stubble examined were infested by the corn borer at the rate of 8.27 borers to each 100 stubble in the field. In the fields representing maximum infestation there were 32.8, 23.8, and 22 per cent, respectively, of the stubble infested. In the 27 fields the corn stubble ranged from 5.5 to 22.9 inches in height, with an average of 12 inches. Twenty-two of the fields were hand cut and five were machine cut. Five hundred stubble were dissected in each field, and from these examinations it was estimated that about 122,576 borers, an average rate of 793 borers for each acre, were present in the stubble of the 27 fields. In nine of these fields, where previous examinations had been made in the cornstalks before cutting, it was determined that 18.76 per cent of the original larval population was left in the stubble.

It is thus evident that unless the numbers of borers left in the stubble of these and of similar fields are reduced greatly by the recommended control measures, a marked increase in corn-borer infestation may be shown in 1927.

Experiments in New England

It appears that the reaction of the two-generation larvæ in New England, when plowed under, differs in some important respects from the reaction of the one-generation larvæ in the Lake Erie region when similarly treated. In Ohio and western New York the larvæ which are plowed under or buried remain beneath the surface throughout the winter, and the majority of them migrate to the surface in the spring. In New England the greater proportion of the larvæ which are plowed under or buried in the late fall remain beneath the surface in a living condition and usually within their burrows in the host material until the late winter or early spring, at which time there is a heavy mortality among them. However, when plowed under in the late summer, in the early fall, or in the spring, the larvæ in New England behave the same as do the larvæ in the Lake Erie region (the

behavior of which has already been described), although the migration of larvæ to the soil surface from late September and October plowings is less than from plowings made during the same period in the more western region.

To secure data on the behavior of fall-buried larvæ in New England, a series of experiments has been conducted each year since 1918, at Medford, Mass., wherein infested cornstalks were buried at various depths ranging from 4 to 12 inches. The results were so nearly uniform that in most of the later experiments a depth of 6 inches was adopted as a standard. The majority of these burials have been made at intervals throughout the period extending from September 15 to November 15, in sandy loam soil, sections of cornstalks naturally infested by second-generation larvæ being used. Various types of cages were employed to hold this material, but the most satisfactory type proved to be a wooden-box frame, 19 by 15 inches, sunk 12 inches into the soil, with the bottom left open and with the top covered tightly by 20-mesh copper-wire screen. A narrow strip of corrugated straw-board attached to the inside of the cage, just above the surface of the soil, provided a shelter, or trap, for the larvæ which came to the surface. A series of check burials, without cage restrictions, to determine the possible influence of cage conditions, demonstrated that the behavior of the larvæ in cornstalks buried in the soil near by was essentially the same as that of those buried in cages of this type.

In general these experiments showed that, from cornstalks buried on or about September 15, approximately 15 per cent of the larvæ migrated to the surface before the winter season; from October 1 burials, 7 per cent; from October 15 burials, 3 per cent; and from the burials made November 1 or later, less than 1 per cent. Check burials in soils classified as moist clay, gravely loam, muck, and beach sand gave practically the same results as those in sandy loam, except that the migration upward was less in the sand and loam types than in the relatively moist clay and muck. The majority of the larvæ which did not migrate to the surface in the fall remained in a living condition within their burrows in the buried cornstalks, or in the soil near by, throughout the winter, and only a fraction of 1 per cent migrated upward in the spring. The remainder died from natural causes or were killed by predators before the soil was in condition for plowing. In standing cornstalks from which the buried material originated, and which was used as a check, there was an average larval mortality of 9.9 per cent due to winter killing, parasitism, and disease.

Duplicate burial experiments conducted in western New York (Silver Creek) during the fall of 1921 and 1922, in sandy loam soil which contained considerable quantities of finely broken shale, showed that in this area there occurred a decided migration of the one-generation larvæ to the surface, involving approximately 91 per cent of the total larval content, from cornstalks buried on or about September 1, 83 per cent from similar material buried September 15, 78 per cent from material buried October 1, and 17 per cent from material buried November 1. The results from check burials made in clay loam and in sandy loam without gravel or shale indicated that the soil type exerted no important influence on the ultimate behavior of the buried larvæ, although their movement upwards was somewhat

delayed in the sandy and gravelly loams as compared to the relatively moist clay. The majority of the larvæ which did not migrate to the surface in the fall remained alive throughout the winter in their burrows within the buried cornstalks or in the soil near by and migrated to the surface in April and May of the following spring. In the standing cornstalks and stubble from which this material originated, the larval mortality due to winter killing, parasites, and disease averaged 5.7 per cent.

With respect to the apparent difference in the percentage of fall-buried larvæ which migrate to the soil surface in one-generation areas as compared with two-generation areas, and particularly from late fall burials, no satisfactory explanation can be advanced at this time. Variations in soil type do not appear to offer a satisfactory

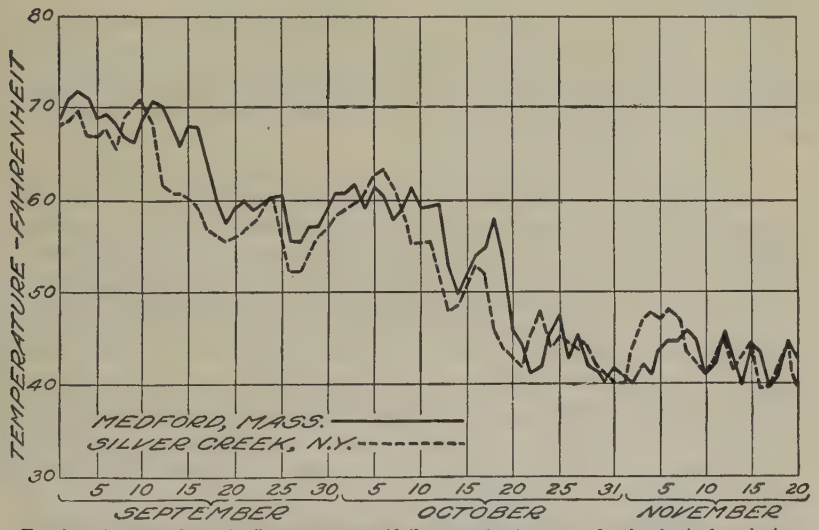

FIG. 34.—A comparison of soil temperatures (daily means) taken at a depth of 6 inches during the period from Sept. 1 to Nov. 20, 1922, at Medford, Mass., and Silver Creek, N. Y.

solution since all experiments have failed thus far to demonstrate any important differences in the behavior of larvæ when buried in various types of soils, except that during the early fall season the upward movement of the one-generation larvæ in moist soil is more rapid than in relatively dry soil. This known influence of soil-moisture content, and the fact that migration of the buried larvæ to the surface is markedly checked after November 1 in the two-generation areas, and perceptibly checked after that date where one generation occurs (coinciding with the lowering of the atmospheric and soil temperatures), very naturally would lead to the possible assumption that the differences in larval behavior could be assigned to variations in these influences. However, a comparison of the temperature records (fig. 34) taken with soil thermographs, at a depth of 6 inches, in the soil used for the experiments at both stations, shows that during the period from September 1 to November 20, 1922, the daily means at Medford, Mass., averaged 3.6° higher in September and 1.4° higher in October than at Silver Creek, N. Y. On the other hand, during the period from November 1 to November 20 the daily means at Silver Creek averaged 0.8° higher than at Medford.

Judging from the evidence presented by these records, particularly those of September and October, it does not seem safe to conclude that soil temperature alone was responsible for the greater activity of the buried larvæ at Silver Creek during that period or during the following spring. A similar comparison of the atmospheric temperature records at the two stations shows that the monthly means averaged about 2 degrees higher at Medford during the period from September 1 to November 30. The total monthly precipitation during this period was very nearly the same at the two stations. It appears, therefore, that the atmospheric temperatures and the precipitation, with the resultant effect upon soil moisture, were very similar at the two stations and that neither of these influences can be held definitely responsible for the difference in the behavior of buried larvæ.

This difference may possibly be due to a difference in the physiological condition of the one-generation and two-generation larvæ at the time of burial, with particular reference to their relative maturity, but an accurate evaluation of this influence must await the completion of further studies.

EFFECT OF PLOWING DURING OR JUST PRIOR TO PUPATION

Spring-burial experiments at Medford, Mass., during the last week of April, 1922, showed that 70 per cent of the larvæ migrated to the surface from cornstalks buried 6 inches deep in sandy loam soil. In the course of duplicate experiments at Silver Creek, N. Y., an average of 44 per cent of the larvæ in cornstalks similarly treated exhibited a similar reaction.

When, however, the burial, or plowing, was delayed in both areas until the majority of the larvæ had pupated, or just prior to that period, only a fraction of 1 per cent of the resulting adults were able to make their way to the surface, and the wings of these were usually deformed.

Unfortunately the farm practice in the areas under observation in New England and in the areas of the Lake Erie region now infested by the corn borer is such that the spring plowing of infested fields usually can not be delayed until the majority of the overwintering larvæ have pupated. Moreover, the adults from the earlier-formed pupæ usually begin emerging before the majority of the overwintering larvæ have pupated or have ceased activity prior to pupation. Where, however, farm practice is such that spring plowing of infested fields can be delayed until the majority of the larvæ have pupated, this practice should prove fairly effective, the degree of effectiveness depending principally upon the percentage of adults which have emerged prior to the plowing and the rapidity with which the larvæ remaining in the plowed-under material cease activity prior to pupation.

EMERGENCE OF MOTHS FROM BURIED LARVÆ OR PUPÆ

Empty pupal cases have often been observed in the remains of infested material which was plowed under in the fall or in the spring and also in material included in small cage burials. Occasional adults also have been found at the surface in cages where infested material was buried as deeply as 12 inches. Relying upon the fact

that pupal cases were found in such buried material, it was concluded that the adults had forced their way through the soil or had followed some opening in the soil to the surface. In more recent experiments, however, a closer examination of the interior of such cages where adults were found on the surface has revealed the presence of pupal cases in small pieces of trash on the surface of the soil or in the crevices of the cage above ground. Presumably these pupæ originated from larvæ which had migrated to the surface from the buried material or had forced their way into the cage from outside.

In order to determine definitely the ability of adults to reach the surface of the soil from pupæ which form in buried material, a series of 60 pupæ in cornstalks was buried at Medford on May 19, 1921, in sandy loam soil at depths varying from 1 to 12 inches. A similar series of free pupæ was buried in wire-screen cylinder cages with screw tops. The soil at the surface of these cages was slightly packed and the cages were exposed to outdoor conditions. From the series of pupæ in cornstalks a single male came to the surface from a depth of 1 inch and another male from a depth of 2 inches. The wings of these adults were deformed. No moths came to the surface from the series of free pupæ. Upon examining the contents of the cages on June 14 it was found that 28 (46.6 per cent) of the adults had issued from the pupæ in stalks and were dead in their burrows or in the soil near by. The remaining pupæ had perished as such. From the free pupæ 9 (15 per cent) of the adults had issued and were dead in the soil near by, while the remaining pupæ had perished and were covered with mites. It is apparent that the adults have difficulty in forcing their way through even an inch of soil under field conditions, although where they are aided by the loose character of the soil, such as would be caused by undecayed or partially buried plant remnants, it is believed that occasional adults may emerge from a greater depth.

Field Observations In New England

Field experiments in thoroughly plowing under infested material in New England during the fall have shown a great reduction in the percentage of living larvæ present in the spring in the small portion of trash remaining upon the soil surface, in comparison with check areas not plowed. The subsequent lighter infestation in the plowed areas during the following season has usually reflected a direct benefit from this practice, although the presence of other factors, such as the use of early planted corn which functioned as a trap crop and the proximity of infested areas not properly treated, have in some instances led to a severe infestation in the plowed fields by the close of the season.

BURNING INFESTED PLANTS

Burning is obviously an effective means of disposing of such infested cornstalks as can not be fed to livestock or plowed under. This method, however, presents certain disadvantages from an agronomic point of view, particularly in regard to the return of organic matter to the soil. When necessary to resort to burning as a method of disposing of surplus cornstalks the procedure will necessarily vary in accordance with the prevailing farm practices in different sections of the infested area.

Where the corn is cut and shocked, the problem is comparatively simple, since any surplus shocks or piles may be burned where they

are, or, if necessary, hauled to a suitable location and burned, not later than June 1. This should include all cornstalks used in building shelters for livestock, for thatching (fig. 35) and for similar purposes. When cornstalks, or other infested plants, are collected in large stacks or piles during the fall, winter, or early spring and left out-of-doors exposed to rain or snow, the excessive moisture accumulating in

FIG. 35.—A, wire cornerib thatched with cornstalks. Erie, Mich., May, 1926. B, standing cornstalks poled down during the winter, raked into windrows, and burned, followed by disked oats. A large percentage of the original larval population left in the débris

the interior of such masses of stalks often causes the larvæ in the center to migrate as soon as they become active in the spring and to enter the comparatively dry stalks composing the top and sides of the pile. Experiments in Hungary and New England have shown that from cornstalks piled densely in November, practically 100 per cent of the total larvæ contained in the pile had migrated into the stalks composing the outer layers before the middle of the following April. The outer stalks were dry enough to burn readily before May 1, and the moisture-

saturated stalks which did not burn were found to be practically free from living larvæ. If for any reason the larvæ are not concentrated in the dry portion of the piles to be burned, as just described, it becomes necessary to spread out the stalks to dry before burning them.

Where the ears are husked from standing stalks the problem of burning the stalks is more difficult. Even here, however, the point to keep in mind is that all corn remnants should be fed, plowed under cleanly, or burned. When the burning of these standing stalks is the best solution of the problem under existing conditions, several methods of procedure are possible. The stalks may be cut as low as possible (and at any event not more than 2 inches high) with a corn binder equipped with a low-cutting attachment, with a "float", with a mowing machine, or with a hoe in the case of small fields where such a method is practicable. Then as soon as they are dry they should be raked into windrows, preferably raked two ways, and burned. Probably the simplest method in most sections now infested by the corn borer would be to break over or "pole down" the stalks with an iron rail, a log, or a planker when the stalks are brittle with frost during the winter or early spring. They should then be raked and burned.

Although field observations have shown that poling, raking, and burning, when conducted carefully and under ideal conditions, resulted in the destruction of a very high percentage of the larvæ present in the field, an analysis of larval survival and mortality in typical cornfields within the infested area of the Lake Erie region indicated that this method, as ordinarily practiced on farms (fig. 35, B), left a high percentage of larvæ alive, unless followed by clean plowing. Results from the examination of 11 typical fields where this method was used, and followed by disking, in the winter and spring of 1926, are shown in Table 23. These examinations were made in northwestern and north-central Ohio. The figures from each field are based upon a careful examination of all plant débris on the surface of 5 square rods of the field, 1 square rod in the center of the field and 1 square rod in the center of each quarter of the field. From the average number of living larvæ per square rod the population per acre was computed and compared with the original larval population per acre before treatment

TABLE 23.—*Larval survival and mortality in fields where cornstalks were poled down, raked into windrows, and burned, and this followed by disking*

Field No.	Date examined (1926)	Borers per square rod in débris	Estimated borers per acre in débris	Estimated borers per acre before treatment	Larval survival	Larvæ killed by treatment [1]
		Number	*Number*	*Number*	*Per cent*	*Per cent*
1	May 18	7.8	1,248	3,148	39.6	60.4
2	May 20	6.2	992	3,434	28.9	71.1
3	May 21	6.8	1,088	2,832	38.4	61.6
4	May 24	3.8	608	1,050	57.9	42.1
5	May 26	1.8	288	628	45.9	54.1
6	do	8.6	1,376	3,194	43.1	56.9
7	May 27	2.4	384	928	41.4	58.6
8	do	6.4	1,024	1,982	51.7	48.3
9	May 28	5.2	832	1,922	43.3	56.7
10	June 1	9.2	1,472	3,394	43.4	56.6
11	June 2	1.8	288	527	54.7	45.3
Total			9,600	23,039		
Average		5.45	872	2,094.5	41.7	58.3

[1] A small percentage of larval reduction, not exceeding 10 per cent, may be attributed to winter mortality, parasites, predators, and disease.

In these fields many living larvæ were found in pieces of stalks not entirely burned, as well as in those not broken off during the poling or cutting process, and in stalks missed by the rake. Special observations in four of the fields showed that 17.5 per cent, on an average, of the total larvæ in the débris were sheltered in small pieces (fig. 30) of corn husk, leaves, weed stems, etc., which it was not possible to gather with the type of rake ordinarily used for such purpose. The results secured from poling, raking, and burning, as shown in Table 23, represent what may be termed a fair clean-up. However, since only 58.3 per cent of the larvæ were killed in these fields, according to the samples examined, it is evident that whenever it is necessary to adopt this method, special efforts should be made to pole down or cut cleanly, rake cleanly, and burn cleanly. If this fails, it appears that the only solution is to plow under cleanly all débris left on the surface. It is recognized that the plowing of cornstalk or cornstubble fields in which small grains are to be sown is a departure from the prevailing practice in many sections now infested by the corn borer, but from the standpoint of corn-borer control it appears inevitable that rotations must be adopted or devised which will eliminate the practice of disking land that has been in corn.

Poling, Raking, And Burning Very Effective When Followed By Plowing

Observations have shown that where standing stalks were poled down, raked in windrows, and burned, and the remaining plant débris plowed under, a very high percentage of the contained larvæ were killed. Results from examinations of typical fields in Ohio and Michigan, where this procedure was followed in the winter and spring of 1926, are shown in Table 24. The method of examination was the same as detailed previously.

Table 24.—*Larval survival and mortality in fields where cornstalks were poled down, raked in windrows, and burned, and this followed by plowing*

Field No.	Date examined (1926)	Borers per square rod in débris	Estimated borers per acre in débris	Estimated borers per acre before treatment	Larval survival	Larvæ killed by treatment [1]
		Number	*Number*	*Number*	*Per cent*	*Per cent*
1	May 26	0.0	0	5,148	0.0	100.0
2	May 28	.4	64	1,939	3.3	96.7
3	June 3	.2	32	1,338	2.4	97.6
4	June 4	.0	0	2,864	.0	100.0
5	June 9	.4	64	910	7.0	93.0
Total			160	12,199		
Average		.2	32.0	2,439.8	1.3	98.7

[1] A small percentage of larval reduction, not exceeding 10 per cent, may be attributed to winter mortality, parasites, and disease.

Although no living larvæ were found in the standard examination of 5 square rods in fields Nos. 1 and 4, it is probable that a more extensive search in each of these fields would have revealed the presence of a few individuals. In the five fields reported upon in Table 24 a kill of 98.7 per cent is indicated from the samples examined, by the combined operations of poling, raking, and burning, followed by plowing. It is obvious that this method, if widely adopted, would act as a very severe check on corn-borer infestation, and therefore it is strongly recommended.

Corncobs, Shelled Corn, and Corncribs

The process of shelling corn does not ordinarily kill the borers contained within the cobs. It becomes necessary therefore to burn all cobs in infested regions not later than June 1 of each year.

All shelled corn intended for shipping out of the infested area should be free of portions of cobs, since such portions are likely to contain the borer, if coming from badly infested fields.

Corn from badly infested fields should be shelled not later than June 1 of the following year and the cobs burned. When it is impracticable to shell such corn before June 1, it should be placed in a tight container or covered by a wire screen, at least 12 meshes to the inch, to prevent the escape of emerging moths.

Cornstalks Stored in Barns and Other Shelters

Although detailed experiments have shown that many of the larvæ contained in cornstalks that were stored indoors died as the result of drying out and the subsequent development of the survivors was delayed, an important percentage of such larvæ completed their development under storage conditions similar to those found on the average farm. The percentage of adult emergence from such material has depended upon several different influences, particularly upon the time of year when the stalks were brought inside, whether the shelter was heated or unheated, prevailing humidity conditions within the shelter, and whether the shelter was tight enough to exclude rain, snow, and other sources of moisture. At Silver Creek, N. Y., on December 20, 1921, H. N. Bartley stored infested cornstalks under the following conditions: (1) In a dry, unheated room; (2) in a dry, heated room; (3) out of doors, in an open insectary, where the cornstalks were under shelter but were exposed to atmospheric humidity and a small amount of precipitation; (4) check material, cornstalks shocked out of doors under natural conditions. Fifty infested cornstalks were used in each lot. Late in the spring of 1922 each lot was inclosed in a wire-screen cage and notes were made upon adult emergence. Up to July 20, 1922, the following adult emergence was recorded, based upon the total larvæ in the stalks as shown by subsequent dissection: Lot 1, 12.3 per cent; lot 2, 21.4 per cent; lot 3, 75 per cent; and lot 4, 69.6 per cent. On July 20 all stalks in each lot were dissected, and a few living larvæ and pupæ were found in each lot. It is evident from the above that the percentage of larvæ able to pupate and successfully emerge as adults was decreased, as compared to emergence in the check material, when stored material was kept under low-humidity conditions, either heated or unheated, and that the percentage of emerging adults was increased, as compared to emergence in the check material, when the stored material was kept out of doors under shelter exposed to atmospheric humidity and limited precipitation. It is believed that the stored cornstalks on farms are stored largely under conditions similar to those of lots 1 and 3.

In further tests to determine the percentage of adult emergence from infested cornstalks stored indoors variable results were secured in accordance with storage conditions, of which the following is typical: On October 26, 1925, L. H. Patch placed 100 cornstalks, containing an expectancy of 93 larvæ, in an ordinary barn at Sandusky, Ohio.

To all appearances this barn was fairly weather tight. The stalks were inclosed in a wire-screen cage, and notes were made upon adult emergence as follows: Eight adults emerged prior to August 7, 1926; 28 adults emerged between August 7 and August 13; and 14 emerged between August 14 and October 4. Dissection of the stalks on October 4 revealed 9 living larvæ, 21 dead larvæ, and 7 dead pupæ, while 6 larvæ had apparently migrated from the material. Check material exposed to natural conditions in the field showed a larval mortality of 6.7 per cent. Of the 93 individuals expected to be in the stalks, a total of 50, or 53.8 per cent, developed and emerged as adults. Of these adults a total of 36, or 38.7 per cent of the total larval expectancy, emerged prior to August 13. In continuing the experiment, 822 eggs, deposited by the adults which emerged during the period from August 7 to August 13, were placed upon dent-corn plants on August 24. Dissection of these plants on October 9 disclosed 50 mature larvæ, 24 immature fifth-instar larvæ, and 1 fourth-instar larva. This gives a survival of larval establishment of 9.1 per cent, which agrees very closely with the percentage of larval establishment on dent-corn plants from eggs deposited earlier in the season.

At Silver Creek, N. Y., a large quantity of infested cornstalks was stored in an ordinary barn, not weather-tight, early in October, 1922. Late in June and in July, 1923, many hundreds of adults emerged from the portion of this stored material which remained unfed. It is significant that four fields of corn in the immediate vicinity of this barn represented the maximum infestation in the Silver Creek section. In these four fields the average number of larvæ per 100 stalks at harvest equaled 76.6, whereas the average for the entire area was 19.8 larvæ per 100 stalks.

Judging from the results of the work as previously described, and from similar experiments and observations, it will be appreciated that corn-borer adults emerging from cornstalks stored in barns and other shelters may become an important source of reinfestation and that such cornstalks should be utilized or destroyed, as a part of the general clean-up.

SEASONAL AND VARIETAL PLANTING OF CORN

Field observations and plot experiments have shown that the degree of corn-borer infestation, as well as the resultant damage to corn, usually is correlated very closely with the time of planting. Corn planted after the first week or 10 days of June, in the Lake Erie region, usually has shown a markedly lighter infestation than earlier plantings. In the two-generation area of New England the early and late plantings have sustained usually the heaviest infestations, irrespective of type or variety, whereas plantings made during the period from approximately May 20 to May 30 in a normal season have usually escaped serious injury. Phenological observations are now in progress which will attempt to discount the vagaries of the seasons by substituting for them plant-development phenomena indicating the most favorable planting period, irrespective of calendar dates.

Concerning the relative susceptibility of types, varieties, or strains of corn, none tested or observed to date has shown any indication of possessing real immunity to corn-borer attack, but those varieties

characterized by large stalks have shown usually a greater tolerance to severe injury by the corn borer than have varieties with smaller stalks. This applies to sweet corn, field corn (dent and flint), and corn grown for fodder or silage. The greater tolerance to corn-borer injury shown by varieties with large stalks as compared to those with smaller stalks, other conditions being equal, is due apparently to their greater volume and rigidity, which enable them to withstand larval injury without so seriously affecting the development of the stalk and ear. Under conditions of severe infestation, however, particularly in Essex and Kent Counties, Ontario, where the larval population per plant in certain fields has averaged from 25 to 50 borers or more, the large-stalked varieties have been so seriously injured as to result in a partial or complete loss of the crop. The tolerance of the large-stalked varieties, therefore, appears to be only relative, in accordance with the degree of infestation to which they are exposed. In some instances it has appeared that certain varieties of field corn or sweet corn were less susceptible to severe corn-borer injury than others, but such comparative freedom from infestation and injury has not been uniform from year to year in any variety under observation.

With reference to the relative susceptibility of various types of corn (sweet, flint, dent), it should be stated that, in many of the areas now infested by the corn borer, sweet corn has been injured usually to a greater degree in a given area than flint or dent corn, and flint usually suffers greater injury than dent corn. Generally, however, the situation is involved with the time of planting, and the physical characteristics of the varieties used, for sweet and flint corn are generally planted earlier than dent corn and are farther along toward maturity when the corn-borer adults are depositing eggs in greatest abundance. Moreover, throughout the areas now infested by the corn borer, the sweet and flint varieties are characterized by smaller stalks than the typical dent varieties, with a consequent variation in tolerance to corn-borer injury as previously described. In general, and with reference to the infested areas as a whole, the corn borer does not appear to exhibit any real preference for any type of corn under equal conditions of exposure to infestation.

Although late planting of corn in the one-generation areas of the Lake Erie region leads to a marked reduction of infestation in both field corn and sweet corn, this practice is not recommended in the case of lightly infested areas, since late planting of the field-corn varieties now in use results in decreased yields, even where proper maturity is attained. There is also the hazard of increased exposure to damage by other insects to be considered in late planting, notably the corn earworm (*Heliothis obsoleta* Fabr.). It is believed that in areas of severe infestation the late planting of corn is an important agronomic means in the restriction of corn-borer damage, within the limits described, and under these conditions it is recommended.

Experiments in Ohio

Experiments were begun in Ohio during 1923, in cooperation with the entomologists and agronomists of the Ohio Agricultural Experiment Station, to determine the effects of seasonal planting on standard and special varieties of field and sweet corn, in relation to

corn-borer infestation; also to determine the relation between the date of planting and yields under conditions of corn-borer infestation. These experiments were conducted near the Bureau of Entomology corn-borer laboratory at Sandusky, Ohio, under the immediate direction of F. W. Poos. In 1923 a series of $\frac{1}{10}$-acre plots, consisting of four varieties of field corn and four varieties of sweet corn, were planted at approximately 10-day intervals from May 1 to June 29 in the case of the field corn, and to July 9 for the sweet corn. Owing to the sparse infestation in the Sandusky area during 1923 no indicative information was obtained. The maximum infestation in any of the plots did not exceed 1 per cent of the plants.

The plot work was continued in 1924 and 1925, and the results are given in Tables 25 to 28. The records pertaining to corn-borer infestation were taken by F. W. Poos and assistants. The yield records were taken by the agronomists under the direction of L. E. Thatcher. Each of these plots was one-fortieth of an acre in size, 5 rows wide and 18 hills long, in light sandy loam soil.

TABLE 25.—*Percentage of plants infested and yields (shelled) of varieties of field corn in experimental plots at Sandusky, Ohio, 1924*

Date planted (1924)	Burr-Learning[1]		Learning		Reid Yellow Dent		Stone Calico		Silver King		Clarage low per cent grain		Clarage		Northwestern Dent[1]		Average	
	Infestation	Yield	Infestation	Yield	Infestation	Yield	Infestation	Yield	Infestation	Yield	Infestation	Yield	Infestation	Yield	Infestation	Yield	Infestation[2]	Yield
	P. ct.	*Bu.*	*P. ct.*	*Bu.*	*P. ct.*	*Bu.*	*P. ct.*	*Bu.*	*P. ct.*	*Bu.*	*P. ct.*	*Bu.*	*P. ct.*	*Bu.*	*P. ct.*	*Bu.*	*P. ct.*	*Bu.*
May 9	4.6	45.2	1.9	44.8	1.5	44.0	4.9	44.7	6.2	36.3	3.6	36.8	3.6	38.5	4.8	15.1	3.5	38.2
May 19	5.7	58.2	1.9	49.4	4.4	60.0	6.2	47.1	9.2	45.6	3.3	46.4	1.4	42.8	0.0	16.9	3.6	45.8
May 29	3.0	54.8	4.1	49.6	1.8	47.0	5.6	45.5	4.6	45.0	1.9	40.2	2.1	40.7	3.2	21.4	2.8	43.0
June 10	0.4	52.3	0.2	42.9	1.7	32.6	2.9	36.1	1.3	37.3	1.3	34.1	2.3	32.7	2.6	17.7	1.3	35.7
June 19	0.0	34.8	0.0	38.0	0.2	29.9	0.2	39.5	0.0	38.4	0.0	33.9	0.6	34.2	0.0	13.3	0.1	32.7

[1] One plot. All others are averages of duplicate plots.
[2] Based on total number of plants in plots.

TABLE 26.—*Percentage of infested plants in varieties of sweet corn in experimental plot at Sandusky, Ohio, 1924*

Variety	Date planted (1924)					
	May 1	May 9	May 19[1]	May 28	June 10[1]	June 20[1]
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Golden Bantam	4.4	2.2	0.7	1.1	0.0	0.0
Stowell Evergreen	1.9	0.4	0.0	0.3	0.0	0.0
Country Gentleman	0.0	0.5	0.0	0.3	0.0	0.0
Average[2]	2.4	1.3	0.3	0.7	0.0	0.0

[1] One plot. All others are averages of duplicate plots.
[2] Based upon total number of plants in plots.

TABLE 27.—*Percentage of plants infested and yields (shelled) of field-corn varieties in experimental plots at Sandusky, Ohio, 1925*

Date planted (1925)	Burr-Leaming		Leaming		Clarage		Van Wye Yellow Dent		Golden Glow		Low-ear selection (Ohio No. 84)		Average[1]	
	Infestation	Yield	Infestation	Yield	Infestation	Yield	Infestation	Yield	Infestation	Yield	Infestation	Yield	Infestation	Yield
	P. ct.	*Bush.*	*P. ct.*	*Bush.*	*P. ct.*	*Bush.*	*P. ct.*	*Bush.*	*P. ct.*	*Bush.*	*P. ct.*	*Bush.*	*P. ct.*	*Bush.*
May 7	1.3	46.2	1.6	41.5	2.6	39.2	2.2	32.2	4.8	32.6	5.5	31.3	3.0	37.2
May 18	0.9	54.7	1.3	46.2	3.2	47.9	4.3	38.0	3.3	36.7	5.2	27.9	3.1	41.9
May 28	1.6	60.8	2.5	57.2	3.6	50.2	3.9	42.7	4.1	42.4	6.3	36.5	3.7	48.3
June 8	1.0	51.9	0.5	46.7	0.3	41.2	0.1	40.3	1.1	37.7	0.7	31.4	0.6	41.5
June 18	0.0	37.2	0.0	35.5	0.0	33.2	0.0	34.0	0.0	33.2	0.5	31.9	0.0	34.2

[1] Based on total number of plants in plots.

TABLE 28.—*Percentage of plants infested in varieties of sweet corn in experimental plots at Sandusky, Ohio, 1925*

[Averages of three plots of each]

Variety	Date planted, 1925					
	April 27	May 7	May 18	May 28	June 8	June 18
Golden Bantam	3.0	5.0	5.0	10.0	0.8	0.0
Red Evergreen	4.4	2.8	2.3	5.5	0.1	0.0
Stowell Evergreen	3.2	1.1	1.4	2.7	0.2	0.0
Average[1]	3.9	3.2	2.9	6.4	0.4	0.0

[1] Averages based on total number of plants in plots.

The results given in Tables 25 to 28 are of course too meager, and the infestation was too sparse, to permit any conclusions being drawn. They are submitted simply as a report upon that phase of the investigations.

At the beginning of the season of 1926 the date-of-planting and varietal tests were transferred from Sandusky, Ohio, to Monroe, Mich., as a portion of the investigations assigned to the new laboratory at that point. They are being continued in cooperation with the agronomists of the Michigan Agricultural Experiment Station.

FIELD OBSERVATIONS IN OHIO

A portion of the data taken during the annual field surveys in Ohio, for the period 1924 to 1926, inclusive, included records of the date of planting in many of the fields of corn where examinations were made later in the season to determine the percentage of infestation and larval population. In all instances recorded, the actual planting date was secured within a few days after the field was sown, and may therefore be considered accurate within limits of a day or two. The fields included in this survey were located in that part of the Ohio area where the corn borer was first discovered in 1921 and 1922, and were well distributed throughout that area. The first survey was made in 1923, and the subsequent surveys from 1924 to 1926, inclusive,

were made in fields on the same farms or on farms near to those examined in 1923. Owing to the sparse infestation prevailing in 1923 no indicative information was obtained, so the details for that year are not presented. The results for 1924 to 1926, expressed in terms of average infestation for fields grouped according to the planting date, appear in Tables 29 and 30. They were reported by F. W. Poos and L. H. Patch, of the Bureau of Entomology laboratory at Sandusky, Ohio.

TABLE 29.—*Comparative infestation of field corn in relation to time of planting, on farms in northern Ohio during the period 1924 to 1926, inclusive*

Dates of planting (inclusive)	Fields examined	Average of plants infested	Larvæ per infested plant	Larvæ per 100 plants [1]
1924	*Number*	*Per cent*	*Number*	*Number*
May 9 to 16	9	4.27	2.20	9.39
May 18 to 23	10	1.97	2.30	4.53
May 26 to 31	22	8.13	1.54	12.52
June 1 to 6	14	1.26	1.75	2.21
June 13 to 20	4	[1] 0.91	1.77	1.61
1925				
May 8 to 15	23	8.08	1.17	9.45
May 16 to 22	30	8.35	1.07	8.93
May 23 to 30	4	19.00	1.30	24.70
June 15	1	0.00	0.00	0.00
1926				
May 4 to 15	8	46.00	2.65	121.90
May 16 to 22	23	32.71	2.75	89.90
May 23 to 31	15	26.42	2.12	56.00
June 1 to 10	5	16.68	2.26	37.70

[1] Includes noninfested as well as infested plants.

TABLE 30.—*Comparative infestation of sweet corn in relation to time of planting, on farms in Ohio during the period 1924 to 1926, inclusive*

Dates of planting (inclusive)	Fields examined	Plants infested	Larvæ per infested plant	Larvæ per 100 plants [1]
1924	*Number*	*Per cent*	*Number*	*Number*
Apr. 19 to 26	8	13.90	2.92	40.58
May 1 to 10	12	7.35	2.40	17.64
May 12 to 20	11	6.60	2.14	14.13
May 22 to June 2	9	6.16	2.36	14.54
June 4 to July 3	11	1.82	1.88	3.42
July 4 to 15	2	0.00	0.00	0.00
1925				
Apr. 9 to 15	7	20.92	1.92	40.17
Apr. 20 to 25	10	17.03	1.29	21.97
May 1 to 10	5	19.60	3.03	59.38
May 11 to 20	20	6.98	2.47	17.24
May 21 to 30	10	2.45	1.43	3.50
June 1 to 7	5	2.88	2.33	6.71
June 7 to 15	6	0.61	1.31	0.80
June 16 to 30	6	0.41	1.28	0.52
1926				
Apr. 21 to 27	3	28.47	3.94	112.17
May 1 to 10	16	32.35	3.02	97.69
May 11 to 20	14	34.44	3.35	115.37
May 21 to 29	10	26.49	2.48	65.69
June 1 to 6	7	14.67	2.22	32.56
June 20 to 25	3	1.15	2.53	2.91

[1] Includes noninfested as well as infested plants.

While the three-year period represented in Tables 29 and 30 does not permit any reliable conclusions with respect to the relation between date of planting and the degree of infestation, under farm conditions, an analysis of the data shows that field or sweet corn planted later than the first week or 10 days of June exhibited a much lower degree of infestation than corn planted earlier; also that a

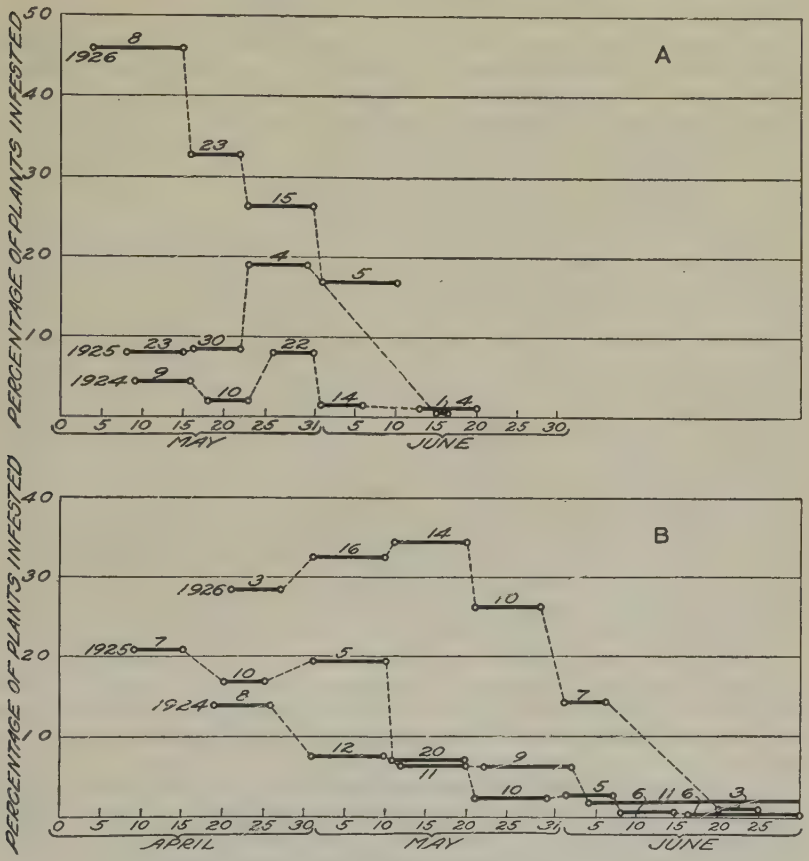

FIG. 36.—A, Relation between time of planting field corn and subsequent infestation, on farms in Ohio during 1924 to 1926, inclusive; B, relation between time of planting sweet corn and subsequent infestation, on farms in Ohio during 1924 to 1926, inclusive

comparatively small number of fields are planted in this area after approximately June 1.

In 1924 and 1925 the maximum infestations in the field corn under observation occurred in fields planted during the last week of May, while in 1926 there occurred a consistent decrease of infestation in the groups of fields planted from May 4 to June 10. In sweet corn, no fixed tendencies were indicated, with respect to early and mid-season plantings, since in 1926 the maximum infestations developed in fields planted during the period from approximately May 10 to May 20, while in 1924 and 1925 there was, in general, a decrease in the degree of infestation from early-planted to late-planted corn. The details reported in Tables 29 and 30 are shown graphically in Figure 36.

Although the relation between the percentage of plants infested and the larval population is not constant in any group of fields represented in the survey, an analysis of the data in Tables 29 and 30, on the basis of larval population, shows practically the same tendencies as comparisons made upon the basis of percentage of plants infested.

Experiments in Massachusetts

On many of the farms and market gardens in the infested area of New England, where sweet-corn plantings are made on successive dates, there usually develops a marked difference in the degree of injury by the corn borer to each successive planting, even where these consist of the same variety in adjoining areas and under similar cultural conditions. In this two-generation area the first planting of early sweet corn, from about April 15 to May 20, usually is injured to a greater degree than plantings made from about May 20 to May 30, while sweet corn, whether of the early or late-maturing varieties, planted later than about the first of June is more seriously injured than any of the earlier plantings, primarily because of its exposure to attack by larvæ of the second generation. Field corn, on the other hand, in the area infested by the corn borer in New England, must be planted as early as weather and soil conditions will permit in order that it may mature before killing frosts. Late planting, therefore, can not be adopted for limiting the degree of injury to field corn in this area, and during a normal season it is exposed to the attack of both generations of the corn borer.

Experiments were begun by the Bureau of Entomology at Medford, Mass., in 1919, to determine the effects of seasonal planting on standard and special varieties of field and sweet corn in relation to corn-borer infestation. Since 1923 the experiments have been carried on at Waltham, Mass., on the Market Garden Field Station, in cooperation with the agronomists of the Massachusetts Agricultural Experiment Station. Emphasis has been placed upon tests of sweet-corn varieties, since sweet corn is of more economic importance than field corn in that part of Massachusetts now infested by the corn borer.

The results of the experiments have been similar from year to year and are well illustrated in the typical example detailed in Table 31, as reported by B. E. Hodgson. The data recorded in this table are based upon an examination of 100 plants from each plot. Counts pertaining to ears are based upon samples of 100 at the roasting-ear stage of development. The tests with slow-growing, late-season varieties, such as Stowell Evergreen and Country Gentleman, have shown that these varieties, even when planted very early, did not reach the roasting-ear stage before becoming seriously infested by the advance guard of the second-generation larvæ. Details regarding the results of experimental tests of sweet and field corn in New England will appear in a separate publication.

TABLE 31.—*Comparative infestation of Golden Bantam sweet corn in relation to time of planting, experimental field at Medford, Mass., 1921*

Date planted (1921)	Examinations for egg clusters		Stalk examinations		Ear examinations		
	Date of examination	Egg clusters per 100 plants	Date of examination	Stalks infested	Date of examination	Ears infested	Ears showing grain injury
		Number		*Per cent*		*Per cent*	*Per cent*
Apr. 28	June 19	13	July 19	58	July 30	18	3
May 12	do	5	do	25	Aug. 4	14	3
May 26	do	0	July 20	6	Aug. 10	3	0
June 9	Aug. 18	250	Aug. 18	100	Aug. 24	62	14
June 23	Aug. 19	162	Aug. 19	100	Sept. 6	82	43

The variation in the amount of injury sustained by sweet corn planted on successive dates may be explained by the fact that, under normal seasonal conditions, very early planted sweet corn of the quickly maturing varieties is well developed and approaching the tassel stage during the period from about June 10 to July 1, which coincides with the maximum oviposition of the first-brood moths. The moths of this brood apparently prefer to deposit their eggs on plants at this stage of development. Sweet corn planted from about May 20 to May 30 is usually not more than 6 or 8 inches high when the first-brood moths are most numerous, and therefore escapes serious infestation and injury by the first generation. It is harvested before the second-generation larvæ become sufficiently numerous or large enough to damage the crop seriously. Sweet corn planted after June 1 is exposed to the attack of the second-generation larvæ, many of which enter the ears soon after hatching, beginning approximately August 1.

FIELD OBSERVATIONS IN NEW ENGLAND

Although it has been repeatedly demonstrated in New England, under both experimental and field conditions, that severe damage to sweet corn apparently may be avoided by regulating the time of planting of early-maturing varieties and abandoning the growing of late-season varieties, much remains to be accomplished in determining what may be designated as a reliable "optimum planting period," without reference to calendar dates, the annual variations in weather conditions which prevail in New England during the early season being kept in mind. In accordance with the phenological theories of A. D. Hopkins, an attempt is being made to solve this problem by correlating the early-season development of certain common trees or shrubs, which react rather quickly and uniformly to the advance of the season, with the "optimum planting period" for escaping maximum damage.

The comparative infestation, under farm conditions, in three fields of Golden Dawn sweet corn planted at intervals during the season on the farm of C. M. Perkins, Winchester, Mass., is shown in Table 32.

TABLE 32.—*Comparative infestation of Golden Dawn sweet corn in relation to time of planting, Winchester, Mass., 1922*

Date planted (1922)	Examinations for egg clusters		Stalk examinations		Ear examinations		
	Date of examination	Egg clusters per 100 plants	Date of examination	Stalks infested	Date of examination	Ears infested	Ears showing grain injury
		Number		*Per cent*		*Per cent*	*Per cent*
Apr. 25	June 22	27	July 26	63	Aug. 8	37	1
May 18	do	7	do	26	Aug. 13	2	0
June 1	Aug. 23	110	Aug. 23	100	Aug. 26	90	28

The dates of corn plantings necessarily vary from year to year according to weather conditions and the local development of the season, but it has been proved possible, even in badly infested districts, to delay the planting of early varieties of sweet corn sufficiently for them to escape severe injury by the first generation of corn borers, and the ears on such delayed plantings can become marketable in time to escape severe injury by the second generation. Unfortunately, a delay in planting very early sweet corn results in an economic disadvantage, however, because early roasting ears command a higher market price than ears produced somewhat later.

The question may well be asked concerning the probable effect on the relative immunity of corn planted in New England from about May 20 to May 30 if all corn plantings were delayed until that period. In this contingency, which seems improbable for economic reasons, it appears evident that the first-brood corn-borer moths would deposit an increased proportion of their eggs on the early developing weeds, which under present conditions already serve as hosts for large numbers of the first generation. This development was well illustrated in the northern border of the infested area in New Hampshire (Concord and Hillsboro) during the season of 1923. Corn is planted late in this region to avoid possible injury by late spring frosts, and because the growing of early market sweet corn is not practicable, so that in 1923 the majority of the first-brood moths were in flight when the earliest planted corn was not more than 6 or 8 inches high. Under these conditions the early developing weeds, particularly Rumex and Polygonum, were infested to a greater extent that even the earliest-planted corn.

In order to obtain information upon the relative susceptibility of different varieties of sweet, flint, and dent corn in Masschusetts, representative varieties of each type have been grown in the experimental field at Medford each year since 1919; also in similar fields at Saugus and Cambridge during 1920 and at Woburn and Belmont during 1921. These experimental fields were located within the area where the insect has become well established, and as the varieties were grown under the same cultural conditions and planted on approximately the optimum planting date for each variety, judged from the experience of growers in the vicinity, the reaction of the insect to each variety and type may be accepted as fairly representing the susceptibility of these varieties to corn-borer attack under New England conditions. Although dent corn seldom is grown for grain

in that portion of New England now infested by the European corn borer, it seemed desirable to include typical varieties of this type for the purpose of comparison. Five of these, including Silvermine, Leaming, Eureka, Johnson County White, and Champion White Pearl, did not mature. The records from the Medford experimental field for 1920 are typical of the results obtained and are included in Table 33.

TABLE 33.—*Comparative susceptibility of varieties of flint, dent, and sweet corn in experimental plots at Medford, Mass., 1920*

Variety	Date planted (1920)	Date harvested (1920)	Stalks infested	Ears infested	Injury to grain	Larvæ per plant [1]
Flint corn:			*Per cent*	*Per cent*	*Per cent*	*Number*
Longfellow	May 14	Oct. 2	90	86.5	3.16	2.4
Early Canada	do	Oct. 5	100	94.6	8.29	7.7
Luce Favorite	do	do	100	96.2	4.70	7.1
Stickney	May 15	Oct. 4	90	95.5	17.93	6.0
8-Row Dutton	do	do	100	94.1	4.30	7.4
Sanford	do	Oct. 2	100	93.2	5.83	8.0
Dutchess White	do	Oct. 7	100	100.0	12.78	40.3
Rhode Island Double Cap	June 5	Oct. 9	100	99.6	15.03	17.4
Average			97.5	94.9	9.00	12.04
Dent corn:						
Leaming	May 14	Oct. 7	90	84.4	2.30	4.0
Brewer Yellow	do	Oct. 15	100	86.4	3.83	6.6
Eureka	do	Oct. 23	100	67.1	.98	7.4
Bloody Butcher	May 15	Oct. 11	40	86.5	2.61	1.1
Pride of the North	do	Oct. 5	100	81.0	2.11	2.8
White Cap Yellow	do	Oct. 25	100	85.5	2.19	5.6
Reid Yellow	do	Oct. 18	100	93.2	3.79	7.3
Funk 90-day	do	Oct. 7	100	83.7	2.96	6.2
Johnson County White	do	Oct. 26	100	86.8	1.66	11.2
Champion White Pearl	do	Oct. 27	100	83.9	2.01	10.0
Silver Mine	do	Oct. 18	100	87.8	3.16	2.8
Calico	June 4	do	100	50.5	2.40	19.6
Average			94.2	81.4	2.50	7.05
Sweet corn: [2]						
Early Hampshire	May 10	Aug. 15	3.0	8.9		
Early Minnesota	do	Aug. 24	5.0	39.3		
Black Mexican	May 20	Aug. 27	2.1	55.1		
Early Cory	do	Aug. 15	3.7	7.5		
Golden Bantam	do	Aug. 20	9.7	24.4		
Pocahontas	do	Aug. 22	14.0	17.9		
Potter Excelsior	do	Aug. 25	14.8	51.6		
Early Crosby	June 1	Aug. 28	29.5	54.8		
Quincy Market	do	Aug. 27	59.1	59.0		
Aristocrat	do	Aug. 30	66.4	78.5		
Early Metropolitan	do	Sept. 10	72.3	99.5		
Stowell Evergreen	do	Sept. 2	82.1	87.5		
Country Gentleman	do	Sept. 11	92.5	98.1		
Average			34.9	52.5		

[1] Ears and ear stems not included.

[2] At roasting-ear stage

The percentages of infestation in flint and dent corn given in Table 33 are based upon an examination of 100 stalks and the entire crop of ears from each variety in plots approximately one-twentieth of an acre in size. In each variety 50 ears were examined for grain injury and 10 plants for number of larvæ per plant. The percentages of infestation in the sweet-corn varieties are based upon an examination of the total complement of ears and stalks in each plot at the roasting-ear stage.

The percentages of stalk infestation in the flint and dent types were nearly equal but the ear infestation and grain injury in the flint

exceeded those in the dent varieties as shown in Table 33. The difference in flint and dent corn injury may be due to difference in maturing dates rather than to inherent qualities in the type. The lower average infestation for sweet corn should not be construed as indicating a lower susceptibility, as this was due to a shorter period of exposure before the ears were harvested at the roasting-ear stage. Although a decided difference in infestation between certain varieties of each type is shown apparently in Table 33, a similar variation in favor of other varieties in the same series was noted during the progress of similar field tests, but no one variety has shown any uniform deviation from the average. For instance, in Table 33 the flint variety Longfellow shows an apparently lower susceptibility to stalk infestation and grain injury than do the other members of the type, whereas in the experimental field at Saugus during 1920, where these tests were duplicated, the stalk infestation in Longfellow (100 per cent) equaled or exceeded that of any of the other flints, and the grain injury (10.84 per cent) was exceeded only by that of Stickney (11.39 per cent). In the dent series the apparently lower susceptibility of Leaming and Bloody Butcher to stalk infestation, and of Eureka to grain injury, did not hold true in similar tests at Cambridge and Saugus during this same year or in subsequent tests.

The variety and type tests in 1922 showed that the two dent varieties, Brewer Yellow and White Cap Yellow, were particularly susceptible to injury when grown under conditions of severe infestation. Brewer Yellow, planted on May 15, suffered a grain injury of 11.7 per cent and contained an average of 38 larvæ per stalk, while White Cap Yellow, planted on May 18, suffered a grain injury of 28.7 per cent and contained an average of 62 larvæ per stalk. One hundred per cent of the ears and stalks were infested in each variety. Longfellow flint corn, planted on the same date and in the plat adjoining White Cap Yellow dent, suffered a grain injury of 17 per cent and contained an average of 58.5 larvæ per stalk.

In the sweet-corn series the degree of infestation in each variety, as given in Table 33, was affected by the dates of planting and maturity. For this reason the early planted and quickly maturing varieties, early Hampshire and Early Cory, show a comparatively low infestation, whereas the later-planted varieties show a corresponding increase. Early Hampshire and Early Cory, planted at Saugus the same year on May 7 and May 20, respectively, showed infestation comparable with that sustained by other varieties planted on the same date. In the majority of the experiments and in commercial fields under observation, Black Mexican suffered less injury than other sweet-corn varieties on approximately the same date and under similar cultural conditions. This tendency was not universal, however, as in some instances the ears and stalks of this variety were injured as severely as other varieties.

METHODS RECOMMENDED FOR MARKET GARDENS IN NEW ENGLAND

The market gardener in a New England district heavily infested with the European corn borer may adopt farming methods that will reduce damage to his crops. It often happens that cultivated crops or weeds on such farms are attractive to moths for oviposition, and plants thus infested are allowed to remain undisturbed during the

winter or until the moths emerge in the spring. By proper management the favorite host plants of the corn borer may be eradicated from the farm and infestation by the borer thus greatly reduced. The methods recommended are to abandon susceptible crops and to substitute quick-growing crops or crops that are not susceptible. Destroy infested plants and crop remnants, keep plowed land free from weeds, and destroy weeds growing around buildings and on headlands.

ABANDONING SUSCEPTIBLE CROPS

Several crops commonly grown on market-garden farms in eastern Massachusetts are favorite host plants of the European corn borer, and furnish food for large numbers of caterpillars of the first generation. The resulting moths deposit eggs on later crops and thus produce a second generation of borers in such crops.

Sweet corn, which is very susceptible to infestation by the borer within the most heavily infested area in Massachusetts, might profitably be abandoned on market-garden farms, except as a trap crop to be disposed of before July 25.

Rhubarb is so attractive to the corn borer that from a standpoint of control it would be advisable to abandon the growing of this crop in badly infested fields, especially where other less susceptible crops may be grown with equal profit.

Plants of the common garden beet are a favorite host of the corn borer, but where grown in the early season and sold as bunch beets, or as greens, they do not remain in the field long enough for the larvæ to mature. For this reason beets may be safely grown in the heavily infested regions only as an early crop but should not be allowed to remain in the field after July 25.

PLANTING QUICK-GROWING CROPS AND CROPS WHICH ARE NOT SUSCEPTIBLE

Crops grown on market-garden farms can be handled in such a manner as to prevent their becoming host plants for the corn borer. Crops that mature quickly, such as early bunch beets, spinach, and green beans, do not furnish favorable conditions for the development of large numbers of corn borers. Celery, tomatoes, potatoes, and peppers are not likely to be injured by the corn borer where the fields are kept free from weeds and where corn or rhubarb is not grown in their immediate vicinity.

Cabbages, carrots, cauliflower, cucumbers, dandelion, eggplants, lettuce, onions, parsnips, peas, radishes, squashes, and turnips are some of the market-garden crops which may be grown in any situation with very little danger of infestation by the corn borer.

KEEPING CULTIVATED LAND FREE FROM WEEDS

Where corn borers are numerous and attack vegetable crops it is necessary for the market gardener to keep his fields free from weeds. Several species of weeds are attractive to the moths for oviposition, and if they are allowed to grow in the fields caterpillars hatching from the eggs laid on them may migrate to adjacent vegetable plants. Beds of spinach often are full of weeds when the crop is ready to

gather, and it is difficult to find borers in the spinach except near infested weeds. Beets are kept more carefully weeded and may be attacked by the corn borer when free from weeds, but are more heavily infested when near pigweed, barnyard grass, or other annual weeds that are allowed to grow in the rows. Bean vines or pods are seldom infested except when grown among weeds. Celery is more often attacked by the corn borer at the ends of the rows or on the outside rows where the plants are adjacent to weeds.

Weeds often come up in the fields after the last cultivation of such crops as squashes, tomatoes, peppers, and potatoes, and are allowed to go to seed and remain undisturbed until spring plowing. Plowing the land in the fall, just after the crop is harvested, destroys the weeds before they produce seed. Such plowing would also destroy the majority of the corn borers.

DESTROYING WEEDS GROWING AROUND BUILDINGS AND ON HEADLANDS

In the Boston market-garden towns several species of weeds are often heavily infested with the corn borer. In the cultivated fields these weeds usually are destroyed by cultivation or are plowed under, thus destroying most of the corn borers. Weeds on the headlands, along fences and ditches, in abandoned garden plots, and around buildings are allowed to grow undisturbed, however, and furnish ideal breeding places where large numbers of moths are produced to infest cultivated crops in neighboring fields. These fields should be plowed as close to the fences and ditches as possible, thus furnishing more land for cultivation and less for weeds. Uncultivated land around buildings should be kept as lawns, and uncultivated fields should be turned into meadow or pasture.

Many of the common host plants of the corn borer which occur on the farm, such as barnyard grass, pigweed, smartweed, cocklebur, and horseweed, may be eradicated if they are kept from going to seed. For this reason it is advisable to mow the weeds along fences and around buildings before seed is produced. In order to destroy the corn borers, the weeds should be cut close to the ground, and should be raked into piles and burned as soon as possible. This usually can be done the day after they are cut. If the mowing is delayed until the weeds are in flower, most of them will be killed. Any weeds which send up new stems or which sprout from new seed may be destroyed in the fall, winter, or spring by burning over such areas with running fire.

As the headlands and land around buildings are usually covered with grass, this grass will crowd out the weeds if mowing and burning are continued for several years. Even perennial weeds like tansy and goldenrod may be displaced by the grass if they are mowed, or sprayed with weed-killing chemicals several times during the season.

Yellow dock is a favorite host plant of the corn borer, especially of the first generation, and should be removed from market gardens in the spring by grubbing.

METHODS EFFECTIVE UNDER SPECIAL CONDITIONS

PROTECTING GREENHOUSE PLANTS IN NEW ENGLAND

Good results have been secured in protecting chrysanthemums and other susceptible plants grown in greenhouses in New England by screening all doors, ventilators, and other openings with screen cloth, cheesecloth, or similar material, in such a manner as to prevent the moths from entering the greenhouse. These screens should be put on before the middle of May and left in position until the middle of September. This method is not effective where the plants become partly grown in infested fields during the summer and are moved into the greenhouse in the fall to complete their growth. Cornstalks, corncobs, large weed stems, and similar plant remnants which are likely to contain the borer should be removed from manure or compost which is intended for use in the greenhouse.

During the fall of 1922 chrysanthemums in several greenhouses under observation became severely infested by borers which migrated into the greenhouse from weeds and flowers growing outside. For this reason it is necessary that the premises adjacent to greenhouses containing susceptible plants should be kept free of weeds and that no susceptible flowers or other crops should be grown within a minimum distance of approximately 50 feet from such greenhouses.

TRAP CROPS

Attention has been directed to the fact that the earliest-sown fields of sweet corn usually sustain the heaviest infestation in any given area, indicating that such fields attract many of the moths which develop from the overwintering larvæ. This naturally suggested the use of a small area of very early planted sweet corn to act as a trap crop in fields intended for a main crop of field corn or later sweet corn. Actual attempts, however, to apply this method of field control have failed thus far to show appreciable benefits which could be attributed solely to trap crops, except under restricted conditions.

Each year from 1924 to 1926, inclusive, L. H. Patch, of the Sandusky, Ohio, corn-borer laboratory, made special observations in Ohio to determine the possible effectiveness of sweet corn as a trap crop for later field corn when planted early in the same field or in adjacent areas. None of these fields were planted with the deliberate purpose of serving as a trap crop, but they functioned practically the same as if intended for that purpose. To serve as a comparison, a few fields also were included which had been planted on the same date as, or a few days later than, the field corn in the same group. The results of these observations, as reported by L. H. Patch, are given in Table 34.

TABLE 34.—*Field observations relating to trap crops of sweet corn as an aid in concentrating infestation by the corn borer, Sandusky, Ohio*

Group No.	Time of planting sweet corn as compared with time of planting field corn	Acreage of—		Infestation in sweet corn		Infestation in field corn		Ratio of larval population of sweet corn to larval population of field corn
		Sweet corn	Field corn	Plants infested	Larvæ per 100 plants[1]	Plants infested	Larvæ per 100 plants[1]	
				SEASON OF 1924				
		Acres	*Acres*	*Per cent*	*Number*	*Per cent*	*Number*	
1	20 days earlier	2.9	3.7	1.00	1.6	0.08	0.1	16.00 to 1
2	30 days earlier	2.7	7.0	1.59	4.6	.20	.4	11.50 to 1
3	do	.2	.7	1.13	1.9	.33	.33	5.76 to 1
4	7 days earlier	2.2	4.4	1.61	6.0	.63	1.1	5.45 to 1
5	21 days earlier	2.4	2.1	1.87	15.7	1.04	3.0	5.23 to 1
6	Same date	1.4	6.4	2.30	3.4	1.13	1.2	2.83 to 1
7	11 days earlier	.7	1.2	22.75	50.1	10.60	21.2	2.36 to 1
8	Same date	.2	.5	8.50	18.7	5.24	8.4	2.23 to 1
9	1 day earlier	7.0	2.6	2.21	4.4	1.48	2.7	1.63 to 1
10	28 days earlier	1.7	2.6	52.00	78.0	32.40	68.1	1.14 to 1
11	Same date	1.5	2.0	15.75	45.7	17.40	40.0	1.14 to 1
12	do	.2	.8	.84	1.4	.63	1.3	1.08 to 1
13	3 days earlier	.8	1.9	10.00	17.0	7.20	2.3	7.39 to 1
14	12 days earlier	.1	.4	9.09	27.3	10.60	38.2	.71 to 1
15	5 days later	2.0	2.0	9.75	23.4	17.40	40.0	.59 to 1
16	21 days earlier	6.9	1.8	5.50	11.5	8.80	20.2	.57 to 1
17	2 days earlier	2.0	4.3	.39	.7	.72	1.3	.54 to 1
18	19 days earlier	3.4	1.3	6.00	10.2	15.25	32.0	.32 to 1
19	17 days later	.3	8.2	.77	2.9	11.60	26.7	.11 to 1
				SEASON OF 1925				
20	18 days earlier	0.7	1.6	10.4	21.84	1.0	1.00	21.84 to 1
21	7 days earlier	25.0	1.6	1.6	2.88	.2	.20	14.40 to 1
22	1 day earlier	.1	5.5	15.4	32.34	2.4	3.12	10.36 to 1
23	29 days earlier	2.7	3.8	21.4	38.52	4.8	3.97	9.70 to 1
24	6 days earlier	.6	4.1	11.4	15.96	2.6	3.12	5.12 to 1
25	38 days earlier	2.9	13.0	25.4	53.34	9.2	11.96	4.46 to 1
26	28 days earlier	2.9	4.3	3.2	5.12	2.0	1.60	3.20 to 1
27	6 days earlier	2.3	1.1	27.0	56.70	17.6	22.88	2.48 to 1
28	35 days earlier	6.3	1.7	10.3	16.48	3.6	7.20	2.29 to 1
29	38 days earlier	10.1	5.8	25.2	27.72	12.4	17.36	1.77 to 1
30	10 days later	.9	3.3	5.0	5.00	5.0	6.50	.59 to 1
31	6 days earlier	.5	.7	1.2	1.92	3.8	6.08	.32 to 1
				SEASON OF 1926				
32	32 days earlier	10.9	6.7	28.6	115.0	8.4	21.0	5.48 to 1
33	16 days earlier	3.3	8.6	27.2	95.2	11.0	20.9	4.55 to 1
34	22 days earlier	6.8	11.5	43.0	167.6	19.0	39.9	4.20 to 1
35	35 days earlier	.7	3.6	91.9	312.5	72.0	79.2	3.94 to 1
36	6 days earlier	4.1	9.5	22.2	122.0	34.8	55.7	2.19 to 1
37	17 days earlier	10.8	2.9	20.8	38.7	21.0	29.4	1.32 to 1
38	Same date	1.4	2.7	44.8	115.6	32.6	97.8	1.18 to 1
39	15 days earlier	1.5	6.3	25.8	49.0	18.4	51.6	.95 to 1
40	3 days earlier	4.5	5.3	16.7	35.6	16.6	41.5	.86 to 1
41	do	.5	1.6	7.0	11.2	14.8	38.5	.29 to 1

[1] Includes noninfested as well as infested plants.

An examination of the data presented in Table 34 reveals that the results, with respect to effectiveness of trap crops, are very contradictory and inconclusive. Although in some groups it appeared that the early planted sweet corn accommodated large numbers of

borers which would have infested later corn in the absence of early-planted corn, this condition was reversed in other groups. The interpretation of results was complicated also in some groups by the fact that unfavorable early-season conditions delayed the development of early-planted corn to such an extent that its advance toward maturity was practically the same as that of later-planted corn at the time of maximum abundance of corn-borer adults.

In the present state of our knowledge, trap crops can not be recommended as an important aid in corn-borer control in the single-generation areas of its occurrence.

Judging from the results secured thus far in the two-generation area of New England, the trap-crop method can be used under New England conditions to advanatge only on the larger fields or farms. On the small farms and market gardens which now predominate in the badly infested two-generation area, any benefits to field corn or late sweet corn to be derived from the trap-crop method appear to have been nullified by the flight of the second-brood moths from adjoining areas of infested vegetables, weeds, or early corn which were not destroyed or utilized as fodder. Even under these conditions, however, the use of a trap crop is advised, as it leads to concentration of the first-generation larvæ. The destruction of these has a tendency to reduce the number of second-brood moths in the immediate vicinity. Infested trap-crop plantings in New England which are not disposed of before approximately July 25 constitute a menace to later corn or to other susceptible crops in the vicinity, as the emergence of the second-brood moths in appreciable numbers begins at approximately this date during a normal season.

The effectiveness of broom millet, or proso, as a trap crop when planted early in the season, was tested at Medford, Mass., and Silver Creek, N. Y., in 1923. This experiment was tried at the suggestion of D. N. Borodin, who stated in conversation that this method was sometimes used in Russia. At Medford a $\frac{1}{20}$-acre plot was planted on April 26 and at Silver Creek a half-acre field was planted on May 3 and a similar field on May 19. In each instance the proso was planted as early as soil and weather conditions would permit. All of the plantings were infested by the corn borer, but the percentage of plants infested by eggs or larvæ was less than that in corn grown in the vicinity. The results did not demonstrate that proso was superior to corn as a trap crop.

INSECTICIDE DUSTS, SPRAYS, AND FUMIGANTS INEFFECTIVE

DUSTS AND SPRAYS

The application of insecticides invariably has proved ineffective in protecting growing corn or other plants from injury by the European corn borer in all experiments conducted up to the present time, although it has been possible to destroy large numbers of the larvæ in their early stages. At this period of their development many of the young larvæ feed upon the surface of the leaf blades (fig. 37), the unopened buds of the tassel, and upon the exposed portions of the husks and silks of the ears. This habit would appear to offer an opportunity to secure a degree of control by insecticidal measures directed against the insect at this juncture. The situation

is complicated, however, by the fact that a considerable proportion of the newly hatched larvæ enter the plant without doing an appreciable amount of feeding on the exterior of the plant. Moreover, the eggs are deposited freely over a period of approximately 15 to 20

FIG. 37.—Feeding areas of newly hatched corn-borer larvæ upon leaf blades of field corn.

days in single-generation areas and over a total period of 30 to 40 days in the two-generation areas. This does not include the total period of egg occurrence in the field but indicates merely the duration of the period when they are found in greatest abundance during a

normal season. Throughout this period the eggs are hatching freely, so that frequent treatments are necessary when directed against the eggs or young larvæ. Although it was realized that the cost of applying insecticides to the main crop of field or sweet corn would probably prove prohibitive under field conditions, it appeared desirable to attempt the development of methods which would be of practical use to market gardeners or seedsmen in protecting crops of high-priced corn.

Experiments in 1918

In preliminary tests at Medford, Mass., small plots of Golden Bantam sweet corn were given the following treatments: (1) One application of lead arsenate (commercial powder) at the rate of 50 pounds per acre; (2) one application of a mixture consisting of equal parts of lead arsenate powder and hydrated lime; (3) one application of calcium arsenate (commercial powder); (4) one application of a mixture of equal parts of calcium arsenate powder and hydrated lime; (5) three applications of lead arsenate spray at the rate of 1 pound of commercial powder to 32 gallons of water; (6) three applications of calcium arsenate spray at the rate of 1 pound of commercial powder to 64 gallons of water. The treatments were timed to coincide with the period of maximum hatching of the larvæ and were given at a time when many of them were feeding upon the leaf blades and upon the unopened buds of the tassel. (Fig. 38.) A comparison of the treated plots with the checks, when the ears were harvested, showed slight decreases in the injury and larval population of the ears and stalks in the plots sprayed with lead arsenate and calcium arsenate, but a 100 per cent infestation developed in the ears and stalks of all plots, and 100 per cent of the ears from all plots were unsuitable for sale.

Fig. 38.—Newly developed tassel of corn plant, showing injury by young larvæ of the European corn borer. Note small gnawed areas on leaves at right caused by feeding of newly hatched larvæ

Experiments in 1919

A series of experiments at Medford, Mass., in applying insecticides to sweet corn gave practically the same results in 1919 as did the tests in 1918. The plots were one-tenth of an acre in size, and the materials were applied with hand dusters and knapsack compressed-air sprayers. The results of this series of tests are given in Table 35.

TABLE 35.—*Dusting and spraying experiments for the control of the corn borer in New England, 1919*

Experiment No.	Material used	Applications	Stalks infested		Ears infested	
			Treated plot	Check	Treated plot	Check
		Number	*Per cent*	*Per cent*	*Per cent*	*Per cent*
1	Magnesium arsenate, dust	4	27.7	29.6	12.2	10.9
2	do.[1]	4	28.3	29.6	14.6	10.9
3	Calcium arsenate, dust	4	33.5	36.9	15.3	18.4
4	do.[1]	4	34.7	36.9	16.2	18.4
5	Calcium arsenate, spray	4	34.4	34.6	12.0	10.9
6	Lead arsenate, dust	4	35.6	30.3	19.4	9.5
5	do.[1]	4	29.8	32.6	9.3	6.7
8	do.[1]	4	31.9	35.5	19.5	9.6
9	Lead arsenate, spray	4	33.4	41.8	15.2	14.3
10	do	4	29.4	46.8	18.2	14.0
11	do	4	31.8	39.9	12.1	9.7
12	do	4	43.0	38.5	22.5	13.0
13	do	4	28.4	23.6	18.2	17.8
14	do	12	23.7	40.9	32.1	33.8

[1] With equal parts of hydrated lime.

The dusts were applied in each treatment at the rate of 50 pounds of the commercial powder per acre. The sprays were applied at the rate of 1 pound of the commercial powder to 32 gallons of water, except in experiment No. 5, where 1 pound to 64 gallons was employed.

The development of the plants and of the insects was watched closely in all plots in an endeavor to apply the treatments when large numbers of larvæ were hatching from the eggs and beginning to feed upon the exterior of the plant. The figures in Table 35, showing comparative infestation in treated plots and in the checks, reveal very little benefit from the application of any of the materials used.

In a field test at Medford, Mass., 5 acres of Early Cory sweet corn were sprayed on June 20 and 21, 1919, with a mixture of magnesium arsenate at the rate of 6 pounds of the commercial powder, and nicotine sulphate (40 per cent) at the rate of 1 pint to 100 gallons of water. The spray was applied with a power outfit under a pressure of approximately 175 pounds. A strip along one edge of the field, approximately 1 acre in area, was left unsprayed, as a check. At the time of the application most of the corn-borer larvæ were in the first, second, and third instars, and many of them were feeding upon the surface of the corn blades and upon or within the buds of the developing tassel. The cost for material, labor, and rental of equipment was computed at $14.34 per acre. At the time of harvest (July 25 to August 3) every ear and stalk was infested in the treated area and in the check. The average larval population per plant in the sprayed and in the check areas was approximately equal, and no appreciable benefit could be credited to the spraying.

EXPERIMENTS IN 1922

The experiments in dusting with calcium arsenate were continued in 1922, and, in addition, several tests were made of dust mixtures containing lead arsenate, sulphur, and hydrated lime in various proportions. Tests were made also of several patented materials which had been advocated as of value in corn-borer control. None of these proved effective in appreciably reducing damage by the corn borer, as will be noted from the data of typical tests appearing in Table 36.

All materials were applied with a hand duster of the bellows type, and each treatment was designed to poison or repel the small larvæ in

the first, second, and third instars, with the exception of experiment No. 2, where the sulphur mixture was employed to test its possible effectiveness in desiccating the eggs or the young larvæ.

The patented preparation referred to in Tables 36 and 37 is a finely ground mica-schist rock, containing small amounts of fertilizing elements. Local growers of sweet corn and other market-garden crops advocated its use as a combined fertilizer and insecticide. Before planting the crop an application of this material at the rate of 1 ton per acre was worked into the topsoil.

TABLE 36.—*Dusting experiments for the control of the corn borer in New England in 1922*

Experiment No.	Material used	Number of applications	Crop treated	Stalks infested		Ears infested		Larvæ per 100 plants [1]		Rate of application per acre
				Treated plot	Check	Treated plot	Check	Treated plot	Check	
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*No.*	*No.*	*Lbs.*
1	Calcium arsenate dust	9	Corn, Brewer Yellow Dent	100	100	96	100	3,920	3,780	450
2	Dust mixture; sulphur 80 per cent, lead arsenate 10 per cent, hydrated lime 10 per cent.	7	Corn, White Cap Yellow Dent.	100	100	100	100	5,910	6,540	350
3	A patented preparation [2]	9	Corn, Longfellow Flint	100	100	100	100	4,530	4,620	1,000
4	do	9	Corn, Brewer Yellow Dent	100	100	100	100	3,960	3,780	1,000
5	do	4	Table beets	92	92	----	----	360	360	100
6	do	7	do	100	92	----	----	720	380	175
7	do	9	do	80	76	----	----	160	460	225
8	do	8	Celery	62	60	----	----	64	36	200

[1] Includes noninfested as well as infested plants. [2] See p. 113, above.

EXPERIMENTS IN 1923

The experiments in 1923 were conducted by W. O. Ellis and assistants. They were confined to tests of various dusts, in an endeavor to develop a dusting material which would function as an ovicide as well as a contact poison, or as an internal poison. The treated plots were kept under close observation, and the dusts were applied at periods when eggs and young larvæ were present in greatest abundance. Like preceding experiments, this series demonstrated the difficulty of keeping rapidly growing corn plants covered with an arsenical during the entire period when the larvæ were hatching and before they entered the plants. Nicotine dusts, when used alone, or in combination with arsenicals and lime or sulphur, gave encouraging results in certain tests applied to sweet corn but were not so effective in applications to field corn. Nitrobenzol dust, 6 per cent (by weight), also gave encouraging results when applied to sweet corn in a single preliminary test.

The materials were applied with hand dusters, including both the blower type and the rotary or fan type.

The prevailing weather conditions during the season of 1923 were very favorable for insecticidal work. For the period from June 1 to October 31 the total precipitation was 6.47 inches less than normal in the Boston district, and the total of sunshine hours was far above normal.

The details of the more important experiments for 1923, as reported by W. O. Ellis, are given in Table 37.

TABLE 37.—*Dusting experiments for the control of the corn borer in New England, 1923*

Experiment No.	Material used (dust mixtures)	Size of plots	Date experiment started (1923)	Applications	Rate of application per acre	Estimated cost per acre (all applications)	Location (Massachusetts)	Type of corn	Stalks infested		Ears infested		Average larvæ per infested stalk		Average larvæ per infested ear	
									Treated plot	Check	Treated plot	Check	Treated plot	Check	Treated plot	Check
		Sq. ft.		*Number*	*Pounds*	*Dollars*			*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Number*	*Number*	*Number*	*Number*
1	Sulphur, lead arsenate, hydrated lime (80–10–10).	7,700	June 4	4	85	9.15	Medford	Sweet	54.9	79.3	27.0	47.0				
2	do	20,000	do	4	57	6.32	do	do	46.2	77.5	30.0	46.0	2.3	8.1	1.2	1.3
3	do	5,300	June 5	4	76	6.52	do	do	36.3	86.9	21.0	32.0	4.1	16.3	1.1	1.0
4	do	2,100	June 20	4	220	21.88	Melrose	Flint	43.0	64.0	42.0	57.0	1.3	2.7	1.5	1.7
5	do	1,250	do	4	270	26.10	do	do	50.0	73.0	44.0	50.0	2.2	3.0	1.8	1.5
6	do	2,000	do	4	225	19.35	do	Sweet	18.0	43.0	1.3	20.1	.9	1.1	1.0	2.2
7	do	2,350	Aug. 21	3	138	12.66	do	do	17.0	37.0	16.6	26.1	1.4	1.8	1.6	1.2
8	Sulphur, calcium arsenate, hydrated lime (80–10–10).	3,600	June 7	4	84	5.68	Medford	do	22.1	82.7	41.0	66.0	7.6	12.0	1.2	1.9
9	do	3,700	do	2	81	6.05	do	do	31.5	66.3	33.0	61.0	5.0	5.7	1.3	1.0
10	do	3,300	do	3	125	8.83	do	do	23.3	66.3	27.0	61.0	4.3	5.7	1.3	1.0
11	do	2,100	July 2	3	140	10.03	Melrose	Flint	41.0	59.0	46.0	62.0	1.9	1.3	1.9	1.8
12	do	1,250	June 20	4	234	15.33	do	do	43.0	73.0	22.0	50.0	2.1	3.0	1.3	1.6
13	do	2,000	July 2	3	133	9.79	do	Sweet	8.7	42.5	1.1	72.9	1.1	2.5	2.0	1.4
14	do	2,350	Aug. 21	2	108	6.96	do	do	29.0	68.0	16.0	77.0	1.3	3.5	1.2	1.6
15	Calcium arsenate, hydrated lime (90–10).	3,200	July 7	2	133	8.09	Arlington	Dent	100.0	100.0	58.6	85.7	9.8	24.4	3.0	3.8
16	do	2,000	do	3	133	6.46	Melrose	Sweet	27.0	47.0	1.9	72.9	1.3	2.2	1.4	1.4
17	do	1,250	do	3	173	12.26	do	Flint	44.0	59.0	39.0	44.0	1.4	2.9	1.8	1.7
18	do	2,350	Aug. 23	2	63	4.45	do	Sweet	16.0	68.0	9.3	77.0	1.2	3.5	1.3	1.6
19	Hydrated lime, lead arsenate, sulphur, 2 per cent free-nicotine dust (70–10–10–10).	10,500	June 13	3	56	5.04	Medford	do	(1)	(1)	31.0	66.0	(1)	(1)	1.2	2.0
20	do	5,500	do	3	53	4.75	do	do	(1)	(1)	30.0	50.0	(1)	(1)	1.2	1.1
21	do	3,200	June 11	3	112	10.80	Arlington	Dent	100.0	100.0	50.8	88.0	11.5	24.9	2.3	4.1
22	do	2,000	June 25	3	140	13.40	Melrose	Sweet	11.0	47.0	5.1	73.0	1.3	2.2	1.3	1.4
23	do	2,350	Aug. 22	3	72	6.78	do	do	13.0	68.0	5.2	77.0	1.0	3.5	1.0	1.6
24	Hydrated lime, calcium arsenate, sulphur, 1 per cent free-nicotine dust (70–10–10–10).	8,100	June 16	3	61	4.96	Medford	do	39.9	70.8	16.0	35.0	6.5	10.7	.7	1.0
25	do	5,000	June 19	3	68	5.38	do	do	31.2	58.9	34.0	70.0	8.7	14.8	1.0	1.0
26	do	2,100	June 20	4	170	15.00	Melrose	Flint	37.0	73.0	39.0	50.0	1.5	3.0	1.5	1.5
27	do	1,250	do	3	218	18.18	do	do	49.0	59.0	17.0	44.0	2.5	2.9	1.1	1.7
28	do	2,000	do	3	176	15.16	do	Sweet	5.0	42.5	3.3	72.9	1.2	2.5	1.1	1.4
29	do	2,350	Aug. 22	2	108	8.88	do	do	23.0	68.0	11.1	77.0	1.1	3.5	1.2	1.6

30	Hydrated lime, calcium arsenate, sulphur, 2 per cent free-nicotine dust (70–10–10–10).	7,000	June 14	3	48	4.10	Medford	do	52.7	74.9	25.0	40.0	2.4	3.7	.8	.9
31	2 per cent free-nicotine dust	2,000	July 7	2	110	21.05	Melrose	do	8.0	82.0	3.9	81.6	.8	1.1	1.1	1.4
32	do	2,350	Aug. 24	1	95	17.58	do	do	15.0	69.0	5.2	74.8	1.4	3.9	1.5	1.7
33	do	2,100	July 11	2	45	8.72	do	Flint	22.0	73.0	23.0	50.0	1.3	3.0	1.3	1.6
34	do	1,250	do	2	60	11.15	do	do	32.0	63.0	37.0	49.0	3.3	3.0	1.5	1.6
35	3 per cent free-nicotine dust	2,350	Aug. 24	1	108	14.00	do	Sweet	11.0	69.0	4.4	74.7	1.1	3.9	1.0	1.7
36	4 per cent free-nicotine dust	2,000	July 7	2	110	14.70	Medford	do	12.0	80.0	4.7	81.6	1.3	2.1	1.0	1.4
37	do	2,100	Aug. 24	1	105	19.70	Melrose	Flint	24.0	73.0	17.0	50.0	1.8	3.0	.8	1.6
38	do	1,250	do	1	70	12.47	do	do	39.0	63.0	21.0	49.0	1.8	3.0	1.4	1.6
39	6 per cent nitrobenzol dust (by weight).	2,350	Sept. 1	1	180	10.44	do	Sweet	20.0	69.0	7.9	74.8	1.4	3.9	1.2	1.7
40	A patented preparation [2]	3,200	June 27	4	960	18.40	Arlington	Dent	100.0	100.0	67.0	57.0	26.8	24.1	2.4	1.8

[1] Corn cut by owner before stalk examination could be made.

[2] See p. 113.

In arranging the plots reported upon in Table 37, four rows of corn were left between plots and checks to act as buffer rows. These blank or buffer rows were found to be effective in preventing an undue amount of dust from drifting from plot to plot or from plot to check. In most of the plots 100 stalks and 100 ears were selected at random for examination to determine the percentage of infestation and larval population. The treatments applied during August and September were of course directed against the second generation.

OVICIDAL EXPERIMENTS

As a preliminary to experiments Nos. 1 to 7, 20 egg masses, where they were, were dusted with a mixture of sulphur, lead arsenate, and lime (80–10–10), to determine the ovicidal value of the mixture. These egg masses were tagged and examined every second day. At the expiration of 10 days 8 of the masses had hatched, 2 masses were parasitized, and the remaining 10 masses became desiccated and dropped off the plants. Since all eggs, except those parasitized, hatched in the check, it is apparent that this dust mixture has some ovicidal value.

In connection with experiments Nos. 31 to 34, 10 egg masses, in natural position, were treated with 2 per cent free-nicotine dust and marked with conspicuous tags. They were examined at intervals of 2 days. At the expiration of 15 days part of 1 egg mass had hatched. Two masses were parasitized, but the parasites were dead within the eggs. The remaining masses had become desiccated and dropped from the plants. Less than 1 per cent of the eggs in the check failed to hatch. Apparently nicotine dust at this strength has decided merits as an ovicide when applied to eggs of the corn borer.

As a portion of experiments Nos. 36 to 38, 10 egg masses were treated, in natural position, with 4 per cent free-nicotine dust. They were tagged and examined as in preceding experiments. At the expiration of 15 days none of the masses had hatched. All had become desiccated and 4 had dropped from the plants. Less than 1 per cent of the eggs in the check failed to hatch.

In similar experiments where three groups of 10 egg masses each in situ were treated with 1 per cent, 2 per cent, and 4 per cent nitrobenzol dust (by weight), respectively, none of the eggs hatched. Less than 1 per cent failed to hatch in the checks. All eggs treated with the dust became deeply wrinkled within a period of approximately 10 days, finally shrinking to only a fraction of the normal size and dropping from the plants. Apparently nitrobenzol dust, at the strengths tested, possesses considerable merit as an ovicide when applied to eggs of the corn borer.

CALCIUM CYANIDE

A single plot of sweet corn was dusted at Medford, Mass., on July 18, with calcium-cyanide dust, at the rate of 25 pounds per acre. The relative humidity at the time of application (10.30 a. m.) was 48 per cent, and the temperature was 82° F. The plants were severely burned by the treatment and failed to develop normally. Another plot of sweet corn at the same place was dusted on July 24 with the same material, at the rate of 35 pounds per acre. The relative humidity at the time of application (2.30 p. m.) was 52 per cent and

the temperature 78° F. These plants were burned severely and failed to develop normally. Two additional plots of sweet corn were dusted with the same material, at rates of 25 and 35 pounds, respectively, per acre, at a time when the plants were wet with dew. The plants in these plots were more seriously burned than were those in the two preceding experiments.

Since this material damaged the plants so seriously in the experiments just described and appeared to be unsuitable for further tests against the corn borer on growing corn, no formal records were made of the mortality to corn-borer eggs or larvæ. Superficial examinations, however, revealed that the surviving plants were severely infested.

Experiments in 1924

The major part of the insecticide experiments in 1924 were confined to sweet corn and were designed as a further test of the materials which gave the most promising results in 1923. They were conducted by W. O. Ellis and assistants. All applications were gauged to coincide with the maximum period of egg hatching and the occurrence of young larvæ on the plants. The materials were applied with hand dusters of the blower type and of the rotary or fan type. The prevailing weather conditions during the season of 1924 were ideal for insecticide application, since the precipitation was less than normal throughout most of the period from July 1 to November 1 and the temperatures were normal, or slightly above normal, in the Boston district.

The details of the more important experiments during 1924, as reported by W. O. Ellis, are given in Table 38.

Table 38.—*Dusting experiments for the control of the corn borer in sweet corn in New England, 1924*

Experiment No.	Material used (dust mixtures)	Size of plots	Date experiment started (1924)	Applications	Rate of application per acre	Estimated cost per acre (all applications)	Tassels infested		Ears infested		Average larvæ per infested ear		Percentage of infestation in check ears minus percentage of infestation in treated ears
							Treated plot	Check	Treated plot	Check	Treated plot	Check	
		Sq. ft.		*No.*	*Lbs.*	*Dolls.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*No.*	*No.*	
1	1 per cent free-nicotine dust	1,150	June 26	3	80	[1] 5.69	49.8	65.7	17.0	36.0	1.2	2.3	19
2	2 per cent free-nicotine dust	1,150	---do-----	3	80	[1] 6.60	36.1	65.7	10.0	36.0	.4	2.3	26
3	Hydrated lime, calcium arsenate with 2 per cent free nicotine (90–10)	1,150	July 1	2	70	7.28	30.0	65.7	9.0	36.0	.8	2.3	27
4	1 per cent free-nicotine dust	2,430	June 26	2	90	[1] 5.37	16.3	22.9	17.0	59.0	1.2	1.4	42
5	2 per cent free-nicotine dust	1,150	---do-----	2	100	[1] 6.78	12.7	22.9	5.0	59.0	.8	1.4	54
6	Hydrated lime, calcium arsenate with 2 per cent free nicotine (90–10)	2,430	July 1	2	80	7.90	12.3	22.9	8.0	59.0	1.0	1.4	51
7	1 per cent free-nicotine dust	6,000	July 2	2	100	[1] 5.64	25.1	77.2	4.0	47.0	1.0	1.5	43
8	2 per cent free-nicotine dust	5,760	---do-----	2	100	6.78	26.5	77.2	9.0	47.0	1.2	1.5	38
9	Hydrated lime, calcium arsenate with 2 per cent free-nicotine dust (90–10)	6,000	July 7	2	100	9.15	17.7	77.2	3.0	47.0	1.3	1.5	44
10	2 per cent free-nicotine dust	8,500	Sept. 1	2	200	10.66	-----	-----	9.0	83.0	1.0	3.4	74
11	-----do-----	10,600	---do-----	2	200	10.66	-----	-----	11.0	78.0	1.1	4.2	67

[1] Cost computed on basis of cost of homemade dust.

Since the experiments detailed in Table 38 were designed primarily to determine whether dusting was a practical proposition when applied to sweet corn destined for table use, particular emphasis was placed upon examinations of the ears at time of harvest. The records pertaining to tassel infestation are useful as indicating the comparative infestation of plots. No records were taken of stalk infestation or of larval population in the stalks. One hundred ears selected at random from each plot were examined to determine ear infestation, and all tassels on four rows of each plot were examined to determine tassel infestation.

The first nine experiments in Table 38 were directed against the first generation of the corn borer in early or mid-season sweet corn, while the last two experiments were directed against the second generation of the insect in late sweet corn. Additional insecticide experiments started at Waltham, Mass., were abandoned because a sparse infestation developed in all plots.

Judging from the results of the 1924 experiments, it appears that nicotine dusts, containing 2 per cent or more of free nicotine, are effective in limiting the injury of valuable crops of sweet corn, when the application of such dust is gauged to coincide with the maximum period of egg hatching and the occurrence of the young larvæ on the plants. The best results were secured in two plots of late sweet corn (experiments Nos. 10 and 11). In these plots, dusted twice with 2 per cent free-nicotine dust, under maximum conditions of infestation, 9 and 11 per cent of the ears were infested, respectively, whereas 83 and 78 per cent of the ears in the checks were infested.

In experiment No. 10 an average of 2 per cent of the grain on the infested ears was injured or destroyed, while on the check an average of 20 per cent of the grain on the infested ears was injured or destroyed. In experiment No. 11 no apparent injury resulted to the grain on the infested ears, while in the check an average of approximately 30 per cent of the grain was injured or destroyed on the infested ears. The cost of the experimental treatment in these two tests was estimated at $10.66 per acre. The cost of the treatment, plus its failure to accomplish effective control, appears to render it impractical for general use.

EFFECT OF NICOTINE DUST UPON CORN-BORER LARVÆ

In the course of field experiments several observations were made to determine the effect of nicotine dust on corn-borer larvæ feeding upon, or within, the treated plants. Observations upon the effect of 2 per cent free-nicotine dust (temperature 75° F.), showed that recently hatched larvæ feeding upon the exterior of the plant or partially exposed within the unopened buds of the tassel were killed within 1 minute after the application of the dust, by the nicotine liberated, without coming in contact with the dust. Larger larvæ, ranging from late first-instar to nearly mature larvæ, were killed within a period of 3 to 5 minutes, when exposed to contact with the dust. In a special test in which sweet-corn plants were treated with 3 per cent free-nicotine dust (temperature 84° F.), 300 larvæ in the first, second, and third instars were dissected from the unopened buds of the tassels and from the feeding webs between the buds of the tassels, 1½ hours after the dust was applied (temperature 86° F.),

and 273, or 91 per cent of the larvæ, were dead at the time of dissection. The remaining larvæ in the group apparently were normal and not affected by the treatment.

Experiments in 1925

The experiments in 1925 demonstrated that the most promising insecticides now available, and the existing methods of applying them, can not be relied upon to produce an efficient and practical control of the corn borer in sweet corn, under conditions prevailing in the infested area of Massachusetts. The season as a whole was favorable for insecticide investigations. Although frequent rains occurred during the summer and early fall, they did not interfere seriously with the application of insecticides during the critical periods in the seasonal development of the corn borer. The experiments in 1925 were performed by W. D. Whitcomb and assistants. The following discussion and data have been taken from his notes:

> The infestation by *P. nubilalis* in the experimental fields was generally too light to produce comparable data regarding the value of the different insecticides. However, the greatest obstacle to satisfactory results appeared to reside in the great variation in degree of infestation within each field. The different plots in the same field were subjected to an unequal attack by the corn borer, with the result that plots treated thoroughly with insecticides developed a heavier infestation than the untreated checks.

The results from the more important experimental tests, as reported by W. D. Whitcomb, are summarized in Table 39.

TABLE 39.—*Insecticide experiments for the control of the corn borer in sweet corn in New England, 1925*

Experiment No.	Material used	Date experiment started (1925)	Applications	Rate of application per acre	Estimated cost per acre (all applications)	Tassels infested		Stalks infested		Ears infested		Average larvæ per infested stalk		Average larvæ per infested ear		Percentage of infestation in check ears minus percentage of infestation in treated ears
						Treated plot	Check	Treated plot	Check	Treated plot	Check	Treated plot	Check	Treated plot	Check	
			Number	*Pounds*	*Dollars*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Number*	*Number*	*Number*	*Number*	
1 [1]	3 per cent free-nicotine dust	June 12	3			25.7	15.8	48.7	51.2	10.0	0.0	0.5	0.4			
2 [1]	2 per cent free-nicotine dust	do	4			23.0	15.8	41.6	51.2	7.5	.0	.3	.4			
3 [1]	Hydrated lime, calcium arsenate, 2 per cent free-nicotine dust (40–10–50).	do	3			9.5	12.2	26.6	20.5	1.6	.0	.1	.1			
4 [1]	Hydrated lime, calcium arsenate, 2 per cent free-nicotine dust (80–10–10).	do	3			16.2	12.2	46.2	20.5	2.4	.0	.4	.1			
5	Calcium fluosilicate (20 per cent pure), dust.	June 19	2	275	19.25	50.0	50.0	40.0	62.0	28.0	16.0	2.2	2.6	1.5	1.4	−12.0
6	Nitrobenzol dust (6 per cent by weight)	do	2	325	12.35	40.0	40.0	59.0	58.0	45.0	26.0	3.7	2.6	2.5	1.9	−19.0
7	Hydrated lime	June 26	2	337	3.40	70.0	40.0	37.0	58.0	31.0	26.0	4.0	2.6	1.5	1.9	−5.0
8	2 per cent free-nicotine dust	do	2	237	30.85	40.0	60.0	36.0	64.0	13.0	30.0	2.9	2.2	1.6	1.7	+17.0
9 [1]	Calcium arsenate, 2 per cent free-nicotine dust (20–80)	June 24	2	300	41.40	11.5	13.2	36.1	24.7	8.3	7.0	.2	.4	1.1	1.6	−1.3
10	Hydrated lime, calcium arsenate, 2 per cent free-nicotine dust (80–10–10)	July 2	1	94	3.55	40.0	30.0	74.0	70.0	43.0	36.0	2.7	4.6	1.2	1.3	−7.0
11	do	do	2			10.0	30.0	84.0	70.0	58.0	36.0	5.2	4.6	1.6	1.3	−22.0
12 [1]	do	June 24	2	350	13.30	6.9	7.5	14.8	32.9	1.7	4.5	.6	.5	1.1	1.0	+2.8
13 [1]	Hydrated lime, calcium arsenate, 2 per cent free-nicotine dust (40–10–50)	do	2	350	30.60	8.7	8.9	20.2	15.3	3.9	4.0	.4	.3	.6	.5	+.1
14	do	July 2	1	94	8.05	20.0	30.0	87.0	85.0	57.0	56.0	4.9	6.9	1.6	1.7	−1.0
15	do	do	2			30.0	30.0	80.0	85.0	65.0	56.0	4.7	6.9	1.3	1.7	−9.0
16	Calcium arsenate, 2 per cent free-nicotine dust (20–80)	July 1	1	63	8.60	20.0	40.0	88.0	87.0	67.0	62.0	4.6	5.5	1.7	1.7	−5.0
17	do	do	2			50.0	40.0	91.0	87.0	69.0	62.0	7.3	5.5	1.4	1.7	−7.0
18	Calcium arsenate	June 26	2	137	23.35	10.0	60.0	33.0	64.0	29.0	30.0	2.1	2.2	1.9	1.7	+1.0
19	Nicotine sulphate (1 to 200), laundry soap (1 to 50), spray	June 18	2		25.20	40.0	70.0	45.0	46.0	21.0	29.0	4.7	2.9	2.0	1.5	+8.0
20	A proprietary paraffin-oil concentrate (1 to 40), calcium arsenate (1 to 50), spray	do	2		12.50	20.0	50.0	42.0	62.0	29.0	16.0	1.7	2.6	1.4	1.4	−13.0

21	A proprietary paraffin-oil concentrate (1 to 40) emulsion, spray	do	2		8.75	40.0	50.0	29.0	62.0	8.0	16.0	2.4	2.6	1.1	1.4	+8.0
22	Calcium arsenate (1 to 50), nicotine sulphate (1 to 200), hydrated lime (2 to 50), spray	do	2		25.85	80.0	40.0	34.0	36.0	18.0	29.0	2.7	2.9	2.0	1.5	+11.0
23	Calcium arsenate (1 to 50), hydrated lime (2 to 50), spray	do	2		1.48	30.0	40.0	39.0	36.0	15.0	29.0	2.5	2.9	1.8	1.5	+14.0
24	Sodium fluosilicate (extra light, 70 to 75 per cent pure), dust	June 19	1	150	12.75	10.0	40.0	40.0	66.0	34.0	31.0	3.1	5.1	2.9	2.0	−3.0
25	Sodium fluosilicate (light, 80 to 85 per cent pure), dust	do	1	275	22.00	40.0	40.0	61.0	66.0	46.0	31.0	3.2	5.1	2.4	2.0	−15.0
26	Hydrated lime, calcium arsenate, 3 per cent free-nicotine dust (80–10–10)	July 2	1	100	4.30	20.0	30.0	88.0	80.0	60.0	58.0	5.9	5.2	1.4	1.5	−2.0
27	do	do	2			20.0	30.0	76.0	80.0	69.0	58.0	2.6	5.2	1.4	1.5	−11.0
28 [1]	do	June 24	2	387	16.60	4.6	8.1	17.2	20.3	2.9	1.1	.3	.5	1.0	1.0	−1.8

[1] Average of duplicate plots.

Experiments numbered from 1 to 4 were on $\frac{1}{10}$-acre plots. The data regarding infestation to tassels, stalks, and ears in this series are based upon an examination of all the plants in 10 alternate hills near the center of each plot. The plots for experiments numbered from 5 to 28 were one-fiftieth of an acre in size. The data regarding infestation in this series are based upon an examination of 100 plants selected at random in each plot. The larval population in each plot of this series was determined by dissecting 10 infested plants from the above group. The dusts were applied with hand dusters of the bellows type, and of the fan or rotary type. The sprays were applied with a compressed-air outfit. Experiments numbered 10, 11, 14, 15, 16, 17, 26, and 27 were directed against the second generation of the corn borer. All others were concerned with the first generation alone. The figures relating to costs are based upon the prevailing retail prices of the different materials used. In small plots there was a tendency to use proportionately more dust than on larger areas, and the applications were intentionally heavy and thorough. These estimates probably would not apply closely to the cost of dusting large fields with power machines.

An analysis of the information presented in Table 39 indicates that the best results were secured with 2 per cent nicotine dust (experiment No. 8). Calcium arsenate, when used as a dust alone and when incorporated with other dust materials or as a spray, appeared to be of some value. It is evident, however, that none of the materials tested to date can be recommended for practical use in combating the corn borer.

INJURY TO CORN BY SODIUM FLUOSILICATE

The application of sodium fluosilicate to corn caused severe injury to the plants. The applications were followed by a heavy rain, which appeared to increase the burning. In order to obtain additional information upon this point, several corn plants were dusted with various strengths of the material, and some of the plants so treated were immediately sprinkled with water from a compressed-air sprayer. The results as shown in Table 40 indicate that moisture increases the injury by sodium fluosilicate, under the conditions of the experiment, but that burning of the plants followed the application in any case.

TABLE 40.—*Injury resulting to corn plants, under wet and dry conditions, from application of sodium fluosilicate at various strengths*

Strength of material (sodium fluosilicate)	Condition of plants	Effect of material on plants
10 per cent active	Dry	Moderate to severe burning.
Do	Wet	Slightly more burning than dry plants.
20 per cent active	Dry	Moderate to severe burning.
Do	Wet	Slightly more burning than dry plants.
70 to 75 per cent active	Dry	Severe burning.
Do	Wet	Do.
80 to 85 per cent active	Dry	Do.
Do	Wet	Do.

EFFECT OF A PARAFFIN-OIL EMULSION ON CORN

A proprietary preparation composed essentially of paraffin oil was used in the spraying experiments on account of the statement of the manufacturers that this material would not injure growing

plants. Laboratory experiments on potted corn plants showed varying degrees of injury following its application and made its use in the field questionable. On June 11 four plots of growing corn, each plot consisting of six hills, were sprayed with the preparation diluted in 20, 40, 50, and 75 parts of water, respectively. The following day the plants sprayed with the 1 to 20 solution showed a suspicious discoloration and all the plants presented an oily appearance. Later, however, the discoloration disappeared, and no permanent injury developed in any of the plants.

EFFECT OF CERTAIN CONTACT INSECTICIDES ON CORN-BORER EGGS

To test further the ovicidal properties of certain contact insecticides on corn-borer eggs, several adult borers were confined over potted corn plants and dock plants (Rumex). After eggs had been deposited upon the plants, the cages and adults were removed and the plants treated. The materials used and the results obtained are shown in Table 41.

TABLE 41.—*Effect of contact insecticides on corn-borer eggs*

Materials used	Eggs failing to hatch	Remarks
	Per cent	
Nicotine sulphate (5 per cent), liquid soap (2 per cent), spray.	100. 0	
Sodium fluosilicate (heavy grade), dust	98. 4	
Sodium fluosilicate (light grade), dust	81. 8	Hatched larvæ died.
Calcium fluosilicate, dust	5. 6	
A proprietary paraffin-oil preparation (1 to 20), spray	100. 0	Slight injury to dock leaves.
A proprietary paraffin-oil preparation (1 to 40), spray	100. 0	Slight injury to corn leaves.
Nicotine sulphate (1 per cent), liquid soap (0.5 per cent), spray.	82. 7	Hatched larvæ died.
Check	13. 2	

The tests reported in Table 41 indicate that nicotine-sulphate soap solution, the paraffin-oil preparations, and sodium fluosilicate have a toxic effect on corn-borer eggs at the strengths tested under controlled conditions.

TESTS WITH CALCIUM CYANIDE IN PLOWING EXPERIMENTS

In connection with the plowing experiments at Bono, Ohio,[4] during the fall of 1925, tests on a small scale were made to determine the possible utility of calcium cyanide in killing corn-borer larvæ contained in plowed-under cornstalks or larvæ which deserted such stalks and worked up to the surface. In three tests, which simulated plowing operations, calcium-cyanide crystals were broadcast at the rates of 124, 62, and 31 pounds, respectively, per acre and raked into the topsoil to a depth of 2 inches. The areas treated, together with a similar area not treated, had been inclosed previously by "recovery traps," and records were made of the larvæ migrating to the soil surface and entering the traps. One hundred larvæ in sections of cornstalks, buried by hand, were used in each test. When the experiments ended, on May 17, 1926, there was no significant

[4] In cooperation with L. L. Huber and C. R. Neiswander, of the Ohio Agricultural Experiment Station.

difference between the percentage of living larvæ recovered from the areas treated with calcium cyanide and that recovered from the check.

FUMIGANTS

Hydrocyanic-acid Gas

The fumigation of infested ear corn and cornstalks with hydrocyanic-acid gas for the destruction of the corn borer proved very unreliable either at atmospheric pressures or under partial vacuum conditions. While an exposure of 24 hours or less at atmospheric pressure, a dosage of 6 ounces of sodium cyanide per 100 cubic feet being used, in most cases killed 100 per cent of the larvæ contained in stalks and ears, there were certain tests in which a small percentage of the larvæ survived exposures of 24 hours, and this treatment proved so unreliable that it can not be recommended for use in treating infested plant products. Under partial-vacuum conditions a small percentage of the larvæ also survived exposure to the hydrocyanic-acid gas treatment regularly adopted for fumigating bales of cotton. The experiments at atmospheric pressure were conducted in a wooden double-walled fumatorium built especially for the purpose and artificially heated. The experiments under partial-vacuum conditions were conducted at the plant of a fumigating company at Somerville, Mass., through the courtesy of R. I. Smith of the Federal Horticultural Board, and the results reported are shown in Table 42.

Table 42.—*Fumigation of ears and stalks of corn with hydrocyanic-acid gas*

AT ATMOSPHERIC PRESSURE

Date	Dosage per 100 cubic feet [1]	Exposure	Temperature of container			Larvæ present		Larvæ killed
			Minimum	Maximum	Mean	Stalks	Ears	
1919		*Hours*	°*F.*	°*F.*	°*F.*	*Number*	*Number*	*Per cent*
Dec. 23	1–2 –4	15	80	118	99.0		60	100.00
1920								
Mar. 2	1–4 –2	21	66	71	68.5	135		100.00
Mar. 8	1– ⅝–4	24	49	61	55.0	212		99.53
Mar. 10	1–2 –4	21	48	55	51.3	85		98.81
Mar. 11	1–3 –4	21	51	57	54.0	66		100.00
Mar. 15	1–2½–4	20	47	50	48.5	61		100.00
Mar. 17	1–1½–2	19	43	53	48.0	90		88.89
Mar. 18	1–1½–2	24	47	59	53.0	175		99.99
Mar. 22	1–1½–2	18	45	54	49.5	67		100.00
Mar. 23	1–1½–2	18	34	62	48.0	60		100.00
Mar. 24	1–1½–2½	18	32	67	50.0	65		100.00
Mar. 26	1–1½–2	18	47	55	51.0	71		100.00
Mar. 27	1–1½–2	18	37	55	46.0	73		97.19
Mar. 29	1–1½–2	24	47	60	53.5	119		99.15
Apr. 2	1–1½–2	24	46	51	48.5	174		100.00
Apr. 7	1–1½–2	24	30	40	35.0	53		100.00
Apr. 7	1–1½–2	24	40	126	83.0	27		100.00
Apr. 10	1–1½–2	24	28	58	38.0	118		100.00
Apr. 12	1–1½–2	24	49	56	52.5	102		100.00
Apr. 16	1–1½–2	24	42	54	48.0	128		100.00

[1] In the formulas given, the first figure is ounces by weight of sodium cyanide, the second is fluid ounces of sulphuric acid, and the third is ounces of water.

TABLE 42.—*Fumigation of ears and stalks of corn with hydrocyanic-acid gas*—Con.

UNDER PARTIAL VACUUM

Date	Dosage per 100 cubic feet	Exposure	Temperature of container			Larvæ present		Larvæ killed
			Minimum	Maximum	Mean	Stalks	Ears	
1919		*Hours*	*°F*	*°F*	*°F*	*Number*	*Number*	*Per cent*
Oct. 22	[2] 1–1 –3	2	50	65	57.5		56	100.00
Do	1–1 –3	2					36	100.00
Dec. 22	1–1 –3	2	22	37	29.5		61	91.80
Do	1–1 –3	2					25	60.00
Do	1–1 –3	2					61	90.16
Oct. 22	1–1 –3	2	50	65	57.5	58		100.00
Do	1–1 –3	2				50		100.00
Do	1–1 –3	2				142		94.50

[2] Regulation cotton fumigation charge. Cyanide used is in solution.

From an examination of Table 42 it may be noted that in general the results were most satisfactory at high temperatures and during the spring after the larvæ had become active, preparatory to pupation. The use of hydrocyanic-acid gas as a fumigant for infested plant products is still under investigation, and possibly a variation in methods may give more satisfactory results.

OTHER FUMIGANTS

Experiments with carbon disulphide, carbon tetrachloride, paradichlorobenzine, and sulphur gave unsatisfactory results, although exposure to carbon disulphide (1 pound per 100 cubic feet, at temperatures above 70° F.) for 24 hours has resulted in killing a very high percentage of the larvæ in small quantities of infested cornstalks and ears of corn. From information available at present, it is not possible to recommend any of these fumigants for the sterilization of plant products infested by the European corn borer.

During the season of 1923 a series of preliminary experiments was conducted to determine the effectiveness of liquid sulphur dioxide as a fumigant at atmospheric pressure. The liquid form of sulphur dioxide is highly unstable, colorless, volatile, and readily reverts to its gaseous form. As a result this chemical is stored, under pressure, in tanks that can be conveniently tapped for the gas when the tank stands vertically or for the liquid when the tank is in a horizontal position.

It was found that a 2 per cent concentration of sulphur dioxide gas by volume would kill, at atmospheric pressure, free corn-borer larvæ and pupæ in a period of 30 minutes when the insects were exposed to the gas in a gas-tight compartment. When the concentration of gas was increased to 100 per cent by volume, a complete kill was secured in one-half minute.

Two and one-half pounds of liquid sulphur dioxide conveyed in the form of gas into a fumigating chamber of 100 cubic feet capacity killed all of the corn-borer larvæ and pupæ present in dry cornstalks and ears in 18 hours. It seems probable that this interval of time might be substantially reduced without changing the results.

Attempts were made also to fumigate badly infested green cornstalks gathered into heaps in the field. In these experiments pieces

of heavy canvas were used to cover the heaps of cornstalks, but this arrangement did not furnish proper conditions because the canvas was not gas proof. For this reason only 98 per cent of the larvæ were killed by a 9-pound charge of the liquid to 40 cubic feet of green cornstalks, although 95 per cent were killed by a 3-pound charge.

Practically identical results were obtained in fumigating infested green cornstalks placed in pits dug in the soil and covered with a waterproof canvas. The substance used to waterproof the canvas apparently covered the fibers of the canvas but did not make the canvas gas tight. The larvæ surviving these pit experiments were always found in cornstalks retaining in part the green color, which indicated that they had been imperfectly exposed to the gas.

It seems doubtful whether sulphur dioxide can be used effectively and in a practical way to fumigate cornstalks in the fields, but it appears to have decided merits as a fumigant when infested material can be treated in a gas-tight compartment. Experiments are contemplated also to test the effectiveness of sulphur dioxide as a fumigant for corn-borer larvæ and pupæ under partial-vacuum conditions.

PASTURING INFESTED CORNFIELDS INEFFECTIVE

In cornfields where cattle, goats, or hogs were allowed to run during the late fall and early spring, a large proportion of the infested cornstalks, stubble, and larger weeds were not consumed, and from present indications this practice can not be recommended as a field-control measure.

In order to test the well-known proclivity of goats for cleaning up plant remnants, three Angora goats were confined on October 26, 1921, in an inclosure 50 feet square containing standing cornstalks which averaged approximately six corn-borer larvæ per stalk. The area also contained a heavy growth of infested barnyard grass, pigweed, lamb's-quarters, and smartweed. The goats were kept there until November 17, and by that time they had eaten off practically all of the corn blades and the tips of the stalks. They had also consumed all of the small weeds and the tips of the larger weeds. An examination of the remaining portions of the cornstalks showed that there were an average of approximately five larvæ per stalk remaining. A few of these cornstalks were eaten down to about one-half their original length, but most of the larger and harder portions of the stalks which normally contain the greater part of the larvæ at this time of the year were not eaten. Toward the last of their confinement the goats spent most of their time in wandering around the inclosure and in trying to escape, paying little or no attention to the hard and dry portions of the cornstalks which remained.

The fondness of hogs for soft-bodied insects is well known, and for this reason it was thought possible that these animals would break open infested cornstalks and other plants in order to secure the larvæ within. On October 3, 1921, two hogs about two-thirds grown were placed in a plot of mature field corn, 50 feet square, which contained an average of approximately six larvæ per stalk and from which all ears had been removed. The hogs were in an active and growing condition and gave every evidence of being good foragers. Only a minimum amount of food was given these animals, and they immediately began rooting up the soil and cleaning up the portions of

ears, nubbins, and green weeds which were present within the area. After a period of one week they had rooted up all the cornstalks and had partly chewed some. As a result, many of the stalks were broken open, and larvæ were seen crawling along the surface of the ground. Special attempts were made to induce the hogs to feed upon them by throwing small handfuls of the larvæ on the ground in front of them, but without success, and under observation the hogs were not seen to devour either these migrating individuals or the larvæ within the stalks. Judging from this experiment, and from observations in "hogged-off" infested cornfields in Ontario and in the Lake Erie States, it is not believed that hogs will prove useful in cleaning up borer-infested cornfields containing mature stalks. Moreover, the activities of hogs usually increase the difficulties of completely plowing under the tangled crop remnants.

HEAT TREATMENT OF EAR CORN INFESTED BY THE CORN BORER

Frequent inquiries have been received from seedsmen, exhibitors, and others, relative to the heating necessary to secure a complete kill of corn-borer larvæ in ear corn.

Preliminary experiments demonstrated that the standard recommendations for destroying by heat the insects infesting stored products were not effective when applied to ear corn infested by *Pyrausta nubilalis*, since the larvæ of this species were found commonly within all parts of the cob. Apparently the cob and its attached kernels functioned as an insulator, necessitating the employment of higher temperatures, and a longer duration of treatment to kill the insects, than would be necessary for insects infesting the kernels alone.

To obtain information upon the various points involved, a series of experiments was carried on at Arlington, Mass., during the winters of 1921–22, 1922–23, and 1923–24 with ears of dent, flint, sweet, and pop corn infested by corn-borer larvæ. These experiments were planned to determine the following: (1) Temperature and time interval required to kill free larvæ; (2) temperature and time required to attain a lethal temperature at center of the cob; (3) time required, at various temperatures, to kill all of the larvæ within infested ear corn; and (4) effect of such heating upon the viability of the seed.

TEMPERATURE AND TIME REQUIRED TO KILL FREE LARVÆ

Free larvæ taken from hibernation were inclosed in small cheesecloth cages and exposed in a heating chamber to constant temperature ranging from 111.2° (44° C.) to 158° F. (70° C.), for various time intervals ranging from one minute to two hours. The relative humidity in the chamber averaged about 50 per cent.

Ten larvæ were used in each trial, at each temperature and time interval tested. For example, at 158° F. 10 larvæ were put in the cheesecloth cage, and the cage was then placed in the heating chamber for one minute. At the expiration of this time the cage was removed, the condition of the larvæ was recorded, and they were then isolated to determine whether subsequent recovery or death would ensue. A fresh lot of 10 larvæ was then exposed in the heating chamber for a

period of two minutes and the procedure just described was repeated. The results of the series of trials are shown in Table 43.

TABLE 43.—*Temperature and time interval required to kill free corn-borer larvæ* [1]

Temperature		Duration of heating period (minutes) and results														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
° *F.*	° *C.*															
158.0	70	S	S	S	S	K	K	K	K	K	K	----	----	----	----	----
154.4	68	S	S	S	S	K	K	K	K	K	K	----	----	----	----	----
150.8	66	S	S	S	S	S	K	K	K	K	K	----	----	----	----	----
147.2	64	S	S	S	S	S	K	K	K	K	K	----	----	----	----	----
143.6	62	S	S	S	S	S	S	K	K	K	K	----	----	----	----	----
140.0	60	S	S	S	S	S	S	S	S	K	K	----	----	----	----	----
136.4	58	S	S	S	S	S	S	S	S	S	S	K	K	K	K	K
132.8	56	----	----	----	----	S	----	----	----	----	S	S	----	K	----	----
129.2	54	----	----	----	----	S	----	----	----	----	S	----	----	----	----	K
125.6	52	----	----	----	----	S	----	----	----	----	S	----	----	----	----	S
122.0	50	----	----	----	----	S	----	----	----	----	S	----	----	----	----	S
118.4	48	----	----	----	----	----	----	----	----	----	S	----	----	----	----	----
114.8	46	----	----	----	----	----	----	----	----	----	S	----	----	----	----	----
111.2	44	----	----	----	----	----	----	----	----	----	S	----	----	----	----	----

Temperature		Duration of heating period (minutes) and results													
		20	25	30	40	45	50	60	70	75	80	90	100	110	120
° *F.*	° *C.*														
132.8	56	K	K	K	----	----	----	----	----	----	----	----	----	----	----
129.2	54	K	K	----	----	----	----	S	----	----	----	----	----	----	----
125.6	52	S	S	S	----	S	----	S	----	----	----	----	----	----	----
122.0	50	S	S	S	----	S	----	S	S	----	S	S	S	S	K
118.4	48	S	----	S	S	----	S	S	----	S	----	S	----	----	----
114.8	46	S	----	S	S	----	S	S	----	----	----	S	----	----	S
111.2	44	S	----	S	S	----	S	S	----	----	----	S	----	----	S

[1] S, one or more larvæ survived; K, all larvæ killed.

According to the results of this series of experiments it appeared that the temperature fatal to free larvæ, for a relatively short period of exposure, ranged from approximately 136.4° F. (exposure of 11 minutes) to 150.8° (exposure 6 minutes). It seemed desirable, therefore, to conduct the remaining trials within these two limits of temperature. The same number of larvæ were used in each trial and the same procedure was followed as in the preceding series. The hibernating larvæ used in this series were stored at constant temperatures of 10°, 50°, and 74° respectively, for a short period before use, in order to ascertain the effect of storage temperature upon the time period and temperature required to secure a lethal effect upon the larvæ when heated. The results are shown in Table 44.

TABLE 44.—*Temperature and time interval required to kill free corn-borer larvæ taken from various storage temperatures* [1]

Temperature constant before treatment	Temperature of treatment		Duration of heating period (minutes)											
			1	2	3	4	5	6	7	8	9	10	11	12
°F.	°F.	°C.												
10	150.8	66		S	S	S	K	K	K					
50						K	K	K	K	K				
74				S	S	S	S	K	S					
10	149.0	65		S	S	S	K	K	K					
50						K	K	K	K	K				
74				S	S	S	S	K	K					
10	147.2	64		S	S	K	K	K	K					
50						S	K	K	K	K				
74				S	S	K	K	S	K					
10	145.4	63		S	S	S	S	K	K					
50							K	K	K	K				
74				S	S	S	K	K	K					
10	143.6	62		S	S	S	S	K	K					
50							K	K	K	K				
74				S	S	S	S	K	S					
10	141.8	61		S	S	S	S	S	K					
50								K	K	K	K	K		
74				S	S	S	S	K	K					
10	140.0	60		S	S	S	S	K	K					
50								S	S	S	K	K		
74				S	S	S	S	S	K					
10	138.2	59					K	K	K	S	K	K		
50										K	K	S	K	K
74							S	S	S	S	S	K		
10	136.4	58					S	S	S	S	S	S		
50										K	K	K	K	K
74							S	S	K	S	S	K		

[1] S, one or more larvæ survived; K, all larvæ killed.

TEMPERATURE AND TIME REQUIRED TO ATTAIN LETHAL TEMPERATURES WITHIN THE COB

While the data in Tables 43 and 44 show that free larvæ succumbed in a relatively short period of time, the fact must be borne in mind that larvæ often are deep within the cobs of corn, and therefore ears of corn must be heated for a sufficient period to attain a lethal temperature in the interior of the cob.

In order to determine the rise of temperature in ears of dent, flint, sweet, and pop corn, specially constructed centigrade thermometers were inserted lengthwise in cobs of each of these types of corn in such a manner that the bulb of the thermometer was in contact with the center of the cob. The ears, with thermometers inserted, were then exposed in a heating chamber to constant temperatures ranging from 104° F. (40° C.) to 212° F. (100° C.) The temperature attained in the centers of the cobs, as shown by thermometer readings observed through the glass window in the front of the heating chamber, were recorded at five-minute intervals. Ten trials were made with each type of corn.

In general, the rate of temperature increase within the cobs of the different types, taken from identical storage conditions, was related to the diameter of the ear. Thus in typical ears of flint corn (Longfellow), sweet corn (Golden Bantam), and pop corn (White Rice), which are characterized by relatively small diameter, there occurred a more rapid rise of temperature than in typical dent-corn ears (Brewer Yellow Dent), which are characteristically larger. The

results of the observations in flint and dent corn ears are shown in Figure 39, each curve representing the average of 10 trials. It should be explained that the ears used in these experiments were harvested in October and were stored out of doors in an insectary well protected from the weather, until they were used for the experiments during the following February and March. Unfortunately, the moisture content of the ears was not determined at the time of the experiment. In later experiments it was observed that the rise of temperature within the ears was affected by their moisture content, relatively dry ears showing a more rapid increase of temperature than ears with a higher moisture content. It was shown also that the rise of temperature within the cobs of corn from which the kernels were removed was more rapid than that in cobs having the kernels in place.

A study of Figure 39 reveals that the rise of temperature within the cobs was very rapid during the first hour of the heating period but

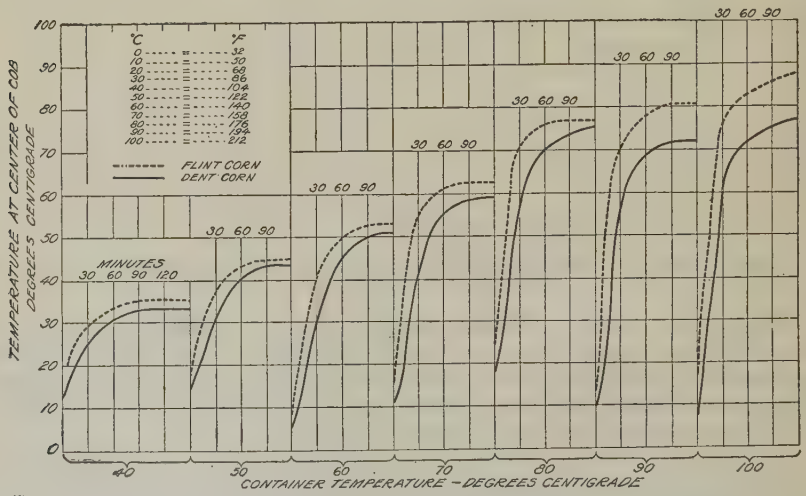

FIG. 39.—The rise of temperature within ears of flint and dent corn at various container temperatures. Broken line represents ears of flint corn. Solid line represents ears of dent corn

was much slower during the second hour, and at the end of a two-hour period the temperature within the cobs had not reached the constant temperature of the container. On referring to the time period and temperature required to kill free larvæ by heat (Tables 43 and 44) and the data pertaining to the time period and temperature required to secure such temperatures within the cob (fig. 40), it seemed possible to deduce the approximate time periods and temperatures required to kill corn-borer larvæ within the cobs of corn. In the case of flint corn at a container temperature of 158° F. (70° C.) the temperature in the center of the cobs reached 140° (60° C.) in approximately 50 minutes. Since Table 43 shows that free larvæ are killed at 140° in about 10 minutes, it appeared possible, theoretically, that all corn-borer larvæ in flint-corn ears would be destroyed when such ears were heated for approximately one hour at a constant temperature of 158°. Similarly, dent corn at the same container temperature (158°) attained a temperature of 136.4° (58° C.) in the

center of the cob in 1 hour and 20 minutes. Since free larvæ were killed at this temperature in approximately 11 minutes it appeared possible, theoretically, that all corn-borer larvæ contained in dent-corn ears would be destroyed when subjected to a constant container temperature of 158° for 1½ hours. Similar comparisons may be made from the other tests at various container temperatures.

Since the most promising results were secured at constant container temperatures of 158° and 140° F. (70° to 60° C.), with due regard to relatively short periods of treatment and temperatures that would not affect adversely the viability of the seed, the majority of the actual heating tests of infested ears were confined to these temperature limits.

TEMPERATURE AND TIME REQUIRED TO KILL LARVÆ WITHIN THE EARS

During the progress of experiments in 1922 it was found to be very difficult to secure a complete mortality of corn-borer larvæ infesting ears where the ears were heated in bulk. These experiments were repeated in February, 1923, with ears of dent, flint, and sweet corn exposed in bulk in bushel baskets to a sustained temperature of 154.4° F. (68° C.). These ears had been harvested the previous October and stored out of doors in an insectary. About 4.3 per cent of the larvæ in these ears were dead from natural causes. It was found that the introduction of the large bulk of ears into the heating chamber lowered the temperature for a short period, so that the ears were not subjected to the desired temperature of 154.4° for the entire time period. Examinations of each type of corn were made at the expiration of 2, 4, 6, 8, 10, and 12 hours from the time the experiment started, and duplicate lots were set aside for examination one week later to ascertain the subsequent death or recovery of the larvæ after the treatment. The examinations one week after the close of the experiment showed that in the flint corn all larvæ had been killed in 10 hours, and that in 12 hours all larvæ in the dent corn had succumbed, but that in the sweet corn a few larvæ survived the 12-hour treatment. It appears that heating ear corn in bulk at this temperature and for this time can not be relied upon to secure a complete mortality of corn-borer larvæ infesting the ears.

In continuing the experiment, infested ears of dent, flint, and sweet corn, similarly harvested and stored, were arranged in single layers on racks, each rack having a capacity of approximately 1 bushel. The racks containing the ears were exposed in February, 1923, to constant temperatures ranging from 145.4° (63° C.) to 158° F. (70° C.), for periods ranging from one-half hour to four hours. The period of treatment in this series was considered as beginning when the ears were placed in the heating chamber. Examinations to determine the effectiveness of the treatment were made immediately upon the completion of the heating period, all larvæ being retained for further observation three weeks after the experiment closed.

An analysis of the results showed in general that at a container temperature of 158° F. (70° C.) all larvæ were destroyed in the flint-corn ears after exposure for two hours but that a few individuals survived in the dent and sweet corn ears. An exposure of two and one-half hours was required to insure a complete mortality in dent and sweet corn.

At 154.4° (68° C.) and 150.8° F. (66° C.) practically the same results were secured, with the exception that a higher percentage of the individuals in the experiment survived at the expiration of the two-hour period in the dent and sweet corn. A treatment of two and one-half hours was required to insure a complete mortality.

At 145.4° F. (63° C.) a single larva survived at the expiration of three hours in flint-corn ears, and an exposure of four hours was required at this temperature to insure a complete mortality in ears of all types.

As a part of this series of experiments, infested ears of dent, flint, and sweet corn were treated in the same manner as that described for the main series, but instead of being dissected immediately upon the completion of the heat treatment they were segregated under favorable conditions and dissected late in June, approximately four months after the close of the experiment. At this time many of the surviving larvæ had developed into pupæ, and a few had issued as adults. Comparison of these with the data from the main series showed substantially the same results with respect to time period and temperature required to secure a complete mortality in infested ears. The natural mortality of larvæ and pupæ in check ears, kept under identical storage conditions, was 6.25 per cent in the dent-corn ears, 10 per cent in the flint-corn ears, and 3.4 per cent in the sweet-corn ears.

In another series of experiments, conducted in a similar manner to the foregoing, where infested ears of dent, flint, and sweet corn were placed in racks and arranged several layers deep, it was determined that not as complete mortality was secured as when the ears were similarly treated in single layers for the corresponding time period and temperature. It seems desirable, therefore, to confine recommendations for heat treatment of ear corn infested by the corn borer to ears arranged in single layers.

Reference has been made to the fact that in preceding tests the time period of treatment was considered as beginning when the ears were placed in the heating chamber, but that a short period of time usually elapsed after the introduction of the ears before the chamber again attained the desired temperature. Since this factor was believed to be responsible for certain variations in the results of some of the experiments, it was decided in the 1924 series to ascertain the results secured when the time period was computed from the time the temperature within the chamber reached the desired point. The experiments were repeated also with the time period beginning with the introduction of the ears. A comparison of the data from the two series demonstrated that the results secured by computing the time period from the time the heating chamber attained the desired temperature were more dependable. The requisites to secure complete mortality of the larvæ were substantially the same as in the 1923 experiments.

In 1924 the experiments were extended to include tests at constant container temperatures of 140°, 136.4°, and 125.6° F. (60°, 58°, and 52° C.), respectively. At 140° a complete mortality was secured at the expiration of 4 hours, at 136.4° the same result was secured in 15 hours, and at 125.6° a complete mortality was not attained in all types of corn after an exposure of 48 hours.

EFFECT OF HEATING UPON THE VIABILITY OF THE SEED

The effect of heat upon the viability of the seed must be considered, of course, in connection with heat treatments designed to destroy corn-borer larvæ inhabiting ear corn. To obtain information upon this point, ears of dent, flint, sweet, and pop corn intended for seed purposes were broken into two parts. These ears had been stored in an unheated room. One-half of each ear was included in the heating experiments where the ears were arranged in single layers, and the other half was retained unheated as a check upon the heated half of the ear. The heated half of the ear was subjected to temperatures ranging from 158° to 125.6° F. (70° to 52° C.), for the same time periods reported upon in the main series of experiments. After the completion of the heating treatment the heated half of the ear and the check were stored in an unheated room.

At the time of planting (May 19 and 20), the seed from the heated half of the ear and the check half of the ear were planted on the same day in adjoining plots at the experimental plots at Waltham, Mass. A uniform number of seed was planted in each hill, and records were kept of the number of seed sprouting in each hill, the number of plants reaching full development, and the number of ears and nubbins produced by each hill at harvest. In general no important differences could be detected in the reaction of the heated and unheated seed, except minor variations in the performance of seed heated at a container temperature of 158° F. For this reason the heating of infested seed corn ears to a temperature of 158° F. has not been included in the recommendations that follow.

Recommendations for Heating Ear Corn Infested by the Corn Borer

In consideration of the facts revealed in the foregoing experiments the following schedule is recommended for the heat treatment of ear corn of any type, infested by the corn borer:

In container having a constant temperature of—	Expose for at least—
154.4° F. (68° C.)	2½ hours.
150.8° F. (66° C.)	3 hours.
145.4° F. (63° C.)	5 hours.
140.0° F. (60° C.)	8 hours.
136.0° F. (58° C.)	24 hours.

Such treatments should be limited to ears arranged in single layers on racks, or a similar arrangement, and the duration of the heating period in each instance should begin at the time the heating chamber attains the designated temperature after the introduction of the ears.

ANNUAL PROGRESS OF INFESTATION

As a part of the investigations to determine the status of the European corn borer as a pest of corn and the annual progress of infestation, surveys of field conditions have been conducted each year in the infested areas of the Lake Erie region and in New England. The surveys were designed primarily to supply information regarding the percentage of plants infested and the larval population in each field examined. In New York and in New England the surveys also included a determination of the percentage of ears infested. An analysis of the data from each area has provided a basis for determin-

ing the approximate increase, or decrease, in the degree of infestation and damage from year to year, and has defined the relative abundance of the insect in different parts of the area. Incidentally the surveys provided data regarding the comparative infestation in different types and varieties of corn and the effect of time of planting under farm conditions, as well as miscellaneous information useful in the conduct of the investigations.

INFESTATION SURVEYS IN THE LAKE ERIE REGION

Prior to 1925 the surveys of cornfields in the Lake Erie region were confined to that portion of the infested area where the insect was first discovered and where it had become fairly well established. In 1925 and 1926, however, a more comprehensive survey was adopted which included the entire area known to be infested by the corn borer in Michigan, Ohio, Pennsylvania, and western New York. These surveys were made just prior to the harvest season in alternate (checkerboard) townships, embracing all conditions of infestation, from the original zone along the margin of Lake Erie to the outer limits of the infested area. Five separate and representative fields, one field approximately in the center of the township and one field approximately in the center of each quarter, were examined for infestation in each township. In choosing fields to be examined in each portion of the township, the selections were made upon the basis of the personal judgment of the field worker as to what constituted fields which were representative of that particular portion of the township. Fields with noticeably poor stands, or which were abnormal in any respect, were eliminated from consideration.

Five hundred plants in units of 100 were examined in each field, one unit in the approximate center of the field and one unit in the approximate center of each quarter of the field. The first plant of each unit was selected at random and from this point a total of 100 consecutive plants were examined in the row. The degree of corn-borer infestation in each field was not known, of course, until the examination was completed. To determine the larval population in each field, 10 infested plants, usually the first 10 infested plants encountered, were dissected.

In fields where less than 10 infested plants were found in the standard examination of 500 plants, the number of infested plants dissected was limited to those actually found. To obtain weighted averages of the percentage of plants infested and the larval population in fields of varying size, in each township or other unit area, the total number of plants in each field was estimated carefully by counting the number of rows in each field and then counting the number of plants in one or more rows. The averages were then computed from the estimated total number of plants in the fields under consideration, the estimated total number of infested plants in such fields, and the estimated total number of larvæ contained in the infested plants. In computing averages the results from all fields examined, whether infested or noninfested, were included.

A summary and comparison of the results from the 1925 and 1926 infestation surveys in Michigan, Ohio, Pennsylvania, and western New York are given in Table 45.

TABLE 45.—*Summary and comparison of the data obtained in the 1925 and 1926 infestation surveys in Michigan, Ohio, Pennsylvania, and New York*

	Michigan		Ohio		Pennsylvania		New York		Total area	
	1925	1926	1925	1926	1925	1926	1925	1926	1925	1926
Townships in survey_number	56	123	150	191	28	38	68	63	302	415
Fields examined_____do	276	613	742	953	140	190	338	315	1,496	2,071
Acreage (approximate)	2,315	4,486	4,663	7,486	484	599	992	964	8,454	13,535
Average plants infested _____per cent	1.10	3.72	1.48	2.17	1.28	1.92	1.56	3.18	[1] 1.35	[1] 2.95
Average larvæ per infested plant_____number	1.36	2.87	1.29	2.49	2.08	3.43	2.87	2.20	[1] 1.56	[1] 2.72
Average larvæ per 100 plants [2] _____number	1.50	10.68	1.91	5.40	2.66	6.59	4.48	7.00	[1] 2.11	[1] 8.02
Increase in average percentage of plants infested		238.2		46.6		50.0		103.8		118.5
Increase in average number of larvæ per infested plant _____per cent		111.0		93.0		64.9		[3] −23.3		74.4
Increase in average number of larvæ per 100 plants [2] _____per cent		612.0		182.7		147.7		56.3		280.1

[1] Weighted averages.
[2] Includes noninfested as well as infested plants.
[3] Represents decrease.

The data presented in Table 45 indicate that, on the basis of the samples examined during the 1926 survey, an increase in larval population equivalent to 280.1 per cent developed during 1926 in the corn-borer infested area of the four States under consideration, as compared with the larval population in the same area during 1925.

An analysis of the 1926 survey, based upon the increase in larval population per township, showed that the increases were well distributed throughout the infested area, and that they occurred with equal frequency and in approximately the same degree in the townships on the higher levels, at a distance from the lakes, as in the townships along the margins of Lakes Huron, Erie, and Ontario.

SPECIAL SURVEYS IN THE OHIO-MICHIGAN AREA

For the purpose of estimating the progress of infestation from year to year in that portion of the Ohio-Michigan area where the corn borer was first found in 1921, a special infestation survey has been conducted each year, beginning with 1922. In the first year, a survey of 75 cornfields well distributed within the area then known to be infested revealed that, in the samples examined, only a fraction of 1 per cent of the plants, on an average, were infested by the corn borer. The maximum infestation in any one field of this series was 2 per cent.

In 1923 this survey was greatly extended, with respect to the number of fields examined, and included some of the townships first found infested in 1922. Although no definite mathematical procedure was employed in the selection of the fields examined during this particular survey, all of the fields were well distributed throughout the area and were selected upon the basis of the personal judgment of the field worker as to what constituted fields which were representative of the locality. Since 1923 the surveys each year have been made in the same fields examined in 1923 or in fields near by, with the primary object of obtaining a history of the development of infesta-

tion in such fields over a series of years. In 1923 and 1924 no definite system was employed in selecting plants for examination in each field, except that the samples were taken from well-distributed and representative parts of each field, but in 1925 and 1926 the same system used in the main survey was used for this special survey. The majority of the fields included in this survey were in Ohio, and the Michigan fields examined were confined to the extreme southeastern corner of the State, adjacent to the Ohio State line.

A summary and comparison of the results obtained from the surveys in the Ohio-Michigan area during the period from 1923 to 1926, inclusive, as reported by F. W. Poos and L. H. Patch, is shown in Table 46.

TABLE 46.—*Summary and comparison of infestation surveys in Ohio and Michigan for the period 1923 to 1926*

Year	Fields examined	Approximate area of fields	Plants infested	Larvæ per infested plant	Larvæ per 100 plants [1]	Maximum of plants infested in any one field	Annual increase in larval population
	Number	*Acres*	*Per cent*	*Number*	*Number*	*Per cent*	*Per cent*
1923	133	443	1.83	1.41	2.58	17.0	
1924	241	702	5.28	1.75	9.24	52.0	258.1
1925	169	1,028	6.93	1.55	10.74	63.8	16.2
1926	192	1,101	23.59	2.53	59.68	91.9	455.7

[1] Includes noninfested as well as infested plants.

An analysis of Table 46 reveals that in the samples examined the number of corn-borer larvæ per 100 plants increased from 2.58 in 1923 to 59.68 in 1926, an increase in larval population of 2,213.2 per cent in three seasons. The increase in larval population in 1926 amounted to 455.7 per cent of the 1925 larval population. Prior to 1926 no appreciable losses had been observed in the infested area of Michigan and Ohio. During 1926, however, limited economic losses occurred in a few fields of dent corn in northwestern Ohio and in occasional fields of sweet corn in northeastern Ohio and along the eastern border of the infested area in Michigan.

SPECIAL SURVEYS IN WESTERN NEW YORK

A special survey, similar to that described for the Ohio-Michigan area, has been followed each year since 1921 in the original area of infestation in western New York, more particularly in the district bordering on Lake Erie and centering at Silver Creek.

A summary and comparison of the results obtained from the surveys in this western New York area during the period from 1922 to 1926, inclusive, as reported by H. N. Bartley and assistants, appears in Table 47. Since complete details regarding the infestation in 1921 were secured from only eight fields, the data for that year have been omitted from the comparison.

TABLE 47.—*Summary and comparison of infestation surveys in western New York for the period 1922 to 1926*

Year	Fields examined	Approximate area of fields	Plants infested	Larvæ per infested plant	Larvæ per 100 plants [1]	Maximum of plants infested in any one field	Annual increase (+) or decrease (−) in larval population
	Number	*Acres*	*Per cent*	*Number*	*Number*	*Per cent*	*Per cent*
1922	14	79	18.90	1.76	33.26	40.4	
1923	30	167	15.16	1.30	19.71	61.0	−40.74
1924	36	223	27.80	2.59	72.00	76.0	+265.30
1925	44	195	39.75	2.18	86.66	83.6	+20.36
1926	53	219	66.80	3.63	242.48	98.6	+179.81

[1] Includes noninfested as well as infested plants.

The data presented in Table 47 indicate that, judged by the samples examined in the original area of infestation of western New York, the larval population increased 629 per cent during the five-year period represented. In comparison with the figures for 1923, an increase of 1,130.2 per cent is shown. During 1926 the estimated commercial loss exceeded 25 per cent in certain fields of dent corn grown for grain in this area, while the loss in discarded sweet-corn ears grown for canning reached approximately the same figure (24.8 per cent).

The preceding discussion and the data in Table 47 relate to infestation in the entire plant, but similar increases of corn-borer infestation were noted in annual examinations made of the ears in the western New York area. During the period from 1921 to 1926, inclusive, examinations were made in most of the fields previously discussed and at various canning factories in the Silver Creek, N. Y., district to determine the extent of infestation in the ears of field (dent) and sweet corn. Whenever possible, the same or near-by fields were used each year. The results of the examinations, as reported by H. N. Bartley and assistants, are given in Table 48.

TABLE 48.—*Progress of infestation in ears of sweet and field corn in the western New York area for the period 1921 to 1926*

Year	Ears examined	Ears infested		Maximum of ears infested in any one field		Annual increase of ear infestation
		Number	Per cent	Field corn	Sweet corn	
	Number			*Per cent*	*Per cent*	*Per cent*
1921	1,400	21	1.50		1.50	
1922	10,182	247	2.43	1.26	5.15	62.00
1923	11,650	640	5.49	7.50	26.60	125.93
1924	12,000	1,083	9.03	42.00	33.20	64.48
1925	18,879	2,192	11.61	9.00	42.00	28.57
1926	13,395	3,407	25.43	75.00	100.00	119.04

Table 48 shows that the ear infestation of field and sweet corn increased 1,595.3 per cent in the western New York area during the period 1921 to 1926, inclusive. If the data for the year 1921 are omitted, when a comparatively small number of ears were examined, ear infestation for the five-year period 1922 to 1926, judged from the samples examined, increased 946.5 per cent.

SPECIAL SURVEYS IN EASTERN NEW YORK

In the original area of infestation in eastern New York, centering at Schenectady, comparable infestation surveys were conducted in the same or near-by fields during 1921, 1922, 1924, and 1926, and the results of the surveys are reported in Table 49. No comparable surveys were made in this area in 1923 or 1925.

TABLE 49.—*Summary and comparison of infestation surveys in eastern New York in 1921, 1922, 1924, and 1926*

Year	Fields examined	Approximate area of fields	Plants infested	Larvæ per infested plant	Larvæ per 100 plants [1]	Maximum of plants infested in any one field	Annual increase (+) or decrease (−) in larval population
	Number	*Acres*	*Per cent*	*Number*	*Number*	*Per cent*	*Per cent*
1921	12	58	8.63	2.51	21.66	15.6	
1922	15	64	7.94	2.38	18.90	38.4	−12.74
1924	30	74	15.07	1.65	24.87	43.6	+31.59
1926	27	95	33.20	3.17	105.24	94.4	+323.16

[1] Includes noninfested as well as infested plants.

Table 49 indicates an increase in intensity of infestation in the original area of eastern New York quite comparable to the increases in the areas infested by the corn borer to the westward. As compared with conditions existing in this area in 1921, the samples examined in 1926 showed that during the interval the number of borers present in the same or near-by fields of this section had increased 385.9 per cent. As compared with that in 1922 the larval population had increased 456.8 per cent. The percentage of ears infested in the fields of this area, judged from the samples examined, increased from an average of 1.81 per cent in 1921 to 5.33 per cent in 1924 and to an average of 16.45 per cent in 1926. The maximum ear infestation in sweet corn in this area in 1926 was 88 per cent, and the maximum ear infestation of field corn was 22 per cent.

A review of the progress of infestation in the Lake Erie region, as shown by comparable surveys made annually from the period beginning in 1922, reveals an alarming increase in the intensity of infestation during this five-year period. While there has occurred an apparent fluctuation in the intensity of infestation from year to year, the general trend has been such as to warrant the belief that the European corn borer has not attained its maximum abundance, nor exhibited its maximum capability as a pest of corn. It is apparent that unless the recommended control measures are universally adopted serious and widespread losses to the corn crop may occur in the very near future.

INFESTATION SURVEYS IN NEW ENGLAND

Field surveys to determine the progress of infestation in New England have been made each year since 1921 in essentially the same manner as described for the areas west of New England. The original selection of towns in 1921 was based upon their geographical distribution with reference to the infested area. An effort was made

to designate towns which were well distributed throughout the area and which represented all conditions of culture and infestation, from the lightly infested towns near the border of the area to the severely infested towns in the center. Owing to the irregular arrangement of the towns, and to their great variation in size, it was not possible, in the New England area, to make selections for survey purposes in a checkerboard manner, or to adopt any similar systematic method. During the first year of this survey the average number of larvæ per 100 plants in each town ranged from 0 to 2,018.1. In 1922 the same or near-by fields were examined in the same towns. Since 1922 the towns surveyed each year have been increased in number, and the survey area has been extended to include the additional areas found to be infested in Massacuhsetts, New Hampshire, and Rhode Island. The selection of the new towns added to the survey was made on the same basis as in 1921, and certain of the towns first examined in 1921 were dropped from the list.

When available, 10 cornfields (or garden patches in the residential districts) were examined in each town. The selection of the fields to be examined was left to the judgment of the field worker as to what constituted fields which were representative of the entire town. In the majority of the towns the irregular occurrence of cornfields prevented any systematic method of distribution in selecting fields to be surveyed. Also in certain of the towns the small amount of corn grown restricted the examination to not more than two or three fields. The general system followed in the examination of each field was the same as described for the more western area except that the small size of the average field in New England restricted the number of plants examined per field to a total of 100 in fields 1 acre or less in size. In fields ranging from approximately 1 to 5 acres, a total of 100 plants for each acre were examined. In fields of over 5 acres, 500 plants were examined per field, the same system as previously described being followed. The majority of the fields examined were of necessity sweet corn, since very little field corn is grown in that portion of eastern Massachusetts, New Hampshire, and Rhode Island now infested by the corn borer.

The results of the surveys during the period 1921 to 1926, inclusive, as reported by B. E. Hodgson and assistants, are given in Table 50.

TABLE 50.—*Summary and comparison of infestation surveys in the entire New England area during the period 1921 to 1926*

Year	Towns in survey	Fields examined	Plants infested	Larvæ per infested plant	Larvæ per 100 plants [1]	Maximum plants infested in any one field	Annual increase (+) or decrease (−) in larval population
	Number	*Number*	*Per cent*	*Number*	*Number*	*Per cent*	*Per cent*
1921	40	397	29.93	4.44	132.89	100.0	
1922	40	398	53.29	8.75	466.29	100.0	+250.88
1923	42	273	16.65	2.76	45.95	100.0	−90.15
1924	46	229	13.46	2.16	29.07	80.0	−36.74
1925	61	293	18.65	3.84	71.62	100.0	+146.37
1926	78	327	13.87	2.14	29.68	98.0	−58.56

[1] Includes noninfested as well as infested plants.

A study of Table 50 reveals a fluctuation in the intensity of the infestation from year to year, as would naturally be expected during a six-year period. The general trend, however, was a pronounced tendency toward a reduction in the numerical abundance of the insect during this period. The 1926 results, on the basis of the samples examined, indicate a reduction in larval population equivalent to 77.66 per cent since 1921. As compared with 1922, the peak of the infestation during the six-year period under consideration, a reduction of 93.63 per cent in larval population is shown. This indicates the presence of approximately one-sixteenth as many larvæ in this area during 1926 as were present in the corresponding area during the peak of the infestation in 1922.

Three important influences believed to be responsible for the general decrease in the intensity of corn-borer infestation in New England may be noted: (1) The universal observance of the Massachusetts "clean-up law," and the lessons learned through the destructive outbreaks of the insect in the past. This brought about the destruction of crop remnants and areas of weeds which had acted formerly as sources of reinfestation. (2) Adverse weather conditions for the corn borer during the greater part of the period 1923 to 1926, particularly a succession of unfavorable early-season conditions which delayed the development of the insect and resulted in the production of only a partial second generation each year. Other adverse influences included the prevalence of cool, dry weather during the periods of adult occurrence, with a consequent diminution in the number of eggs laid, and excessive drought, which resulted in the desiccation of many of the eggs deposited upon the plants. These two influences were particularly effective in 1923, when the mean nocturnal temperatures during the oviposition period of the first-generation adults were below the optimum requirements for oviposition by approximately 10° F., and detailed studies in the field indicated that 11.3 per cent of the second-generation eggs were desiccated. (3) The egg parasite *Trichogramma minutum* Riley destroyed 61.4 per cent of the second-generation eggs in 1923 and approximately 40 per cent in 1926. Birds, particularly the downy woodpecker, *Dryobates pubescens* L., destroyed a high percentage of the overwintering larvæ in localized areas.

SPECIAL SURVEYS IN NEW ENGLAND

As part of the main survey in the New England area, a group of 22 towns distributed throughout the original area of infestation in 1918 were examined each year during the period 1921 to 1926. These towns, which were well distributed throughout the area under consideration, were all included in the 1921 survey reported upon in Table 50. The data from this special group of towns permit a direct comparison of the infestation from year to year in the same or near-by fields in the older portion of the infested area.

The results of the surveys in this group, as reported by B. E. Hodgson and assistants, are given in Table 51.

TABLE 51.—*Summary and comparison of infestation surveys, in the same or near-by fields, in the original area of New England during the period 1921 to 1926, inclusive*

Year	Fields examined	Plants infested	Larvæ per infested plant	Larvæ per 100 plants [1]	Annual increase (+) or decrease (−) in larval population
	Number	*Per cent*	*Number*	*Number*	*Per cent*
1921	222	30.61	2.25	68.87	
1922	217	57.56	6.50	374.14	+443.26
1923	149	24.37	3.36	81.88	−78.12
1924	98	23.32	2.28	53.17	−35.06
1925	111	25.55	2.78	71.03	+33.59
1926	105	17.10	2.12	36.25	−48.97

[1] Includes noninfested as well as infested plants.

The fluctuation in the abundance of the corn borer from year to year in the original area of infestation in New England, as shown in Table 51, paralleled very closely the same trend exhibited when the entire area is considered (Table 50). Judged by the samples examined, the larval population decreased 47.36 per cent during the six-year period. In comparing 1926 conditions with those existing during the peak of the infestation in 1922, a reduction of 90.31 per cent is noted.

A special survey to determine the percentage of ear infestation in commercial fields of sweet corn showed, in general, a decided decrease in the extent of injury to sweet-corn ears at harvest, during the five-year period 1922 to 1926. The fields examined each year were all within the area in which the corn borer has become well established and included most of the fields in the Boston district, where sweet corn was grown on a commercial scale. As far as possible the same or near-by fields were examined each year. For the first three years (1922 to 1924), 100 ears were examined in each field. In 1925 and 1926 a greater number of ears, in units of 100, were examined in the larger fields, while the standard of 100 ears was maintained in the smaller fields. The ears were selected in groups at random in widely separated and representative parts of each field. The results of the surveys to determine ear infestation, as reported by B. E. Hodgson and assistants, are given in Table 52.

TABLE 52.—*Summary and comparison of infestation in ears of sweet corn in the New England area during the period 1922 to 1926, inclusive*

Year	Fields in survey	Ears examined	Ears infested	Maximum of ears infested in any 1 field	Annual increase (+) or decrease (−) of ear infestation
	Number	*Number*	*Per cent*	*Per cent*	*Per cent*
1922	50	5,000	20.4	100.0	
1923	66	6,600	10.6	57.0	−48.04
1924	52	5,200	1.2	28.0	−88.68
1925	61	8,100	6.7	100.0	+458.33
1926	41	5,200	6.0	44.0	−10.45

The information contained in Table 52 is self-explanatory and illustrates conditions prevailing in 1926, as compared with conditions in the same or near-by fields in 1922 and the intervening years. The samples examined indicate a decrease of 70.59 per cent in ear infestation during the five-year period.

Reductions similar to those described for corn were recorded in the infestations of other field crops, vegetables, flowers, and weeds.

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